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THE EXTENT OF HOSPITAL SICKNESS

BY

A. BARR

Oxford Regional Hospital Board

Morbidity studies based on hospital admission rates are complicated because all admissions to a defined group of hospitals rarely come from a defined population and all admissions from a defined population rarely go to a defined group of hospitals. As a consequence, if the starting point of the study is either the complete records of a hospital group or the complete enumeration of the population in a geographical area, the available data are usually precise for either the numerator or the denominator of admission rates but not for both. For a morbidity study the most realistic starting point is the population of a given area, but this is often served by a large number of hospitals both inside and outside its boundaries. As a result, the scrutiny of a mass of medical records is necessary in order that residents of the given area, if admitted to hospital, are included in the survey no matter where the hospital is situated, and in order that non-residents are excluded even though they are admitted to hospitals inside the geographical boundaries of the area studied.

Apart from the practical difficulties of deriving reliable hospital admission rates with numerator and denominator properly related, their interpretation must be made with extreme care. Hospital admissions depend on several factors, such as the number of available beds in various specialties and the attitude of general practitioners and their patients to hospital treatment. Such factors vary between areas; hence what may be true of one area may not be true of another or of the country in general.

The Hospital In-Patient Enquiry (H.I.P.E.)—the 10 per cent. national sample survey of hospital patients organized by the General Register Office on behalf of the Ministry of Health—will enable the variation of hospital sickness between and within areas to be studied. Meanwhile the results of an analysis of all hospital admissions of persons living in a defined area may be of interest. The present paper gives a general analysis of the results. In a future paper, an attempt will be made to relate this analysis with certain social indices.

Previous Investigations

Three reports have been issued using the material gathered in the national inquiry (Mackay, 1951; Registrar General, 1954, 1955), but they do not relate the admissions to specific populations. Although the reports contain much valuable information on such items as the age and sex distribution of admissions for different diagnostic groups, length of stay, and the social grouping of patients, they do not (as yet) give hospital admission rates.

The Nuffield Provincial Hospitals Trust, on the other hand, surveyed the hospital-treated sickness occurring in the Scottish Counties of Stirlingshire and Ayrshire (Nuffield Provincial Hospitals Trust, 1948, 1950). The total volume of hospital sickness was considered in terms of in-patients, in-patient bed days, and out-patients, and the influence of age, sex, social conditions, and domicile were examined. Not much was done, however, in the way of relating the admissions to the population at risk. Rates were given for in-patients and out-patients generally, and for certain diagnostic groups, but no analysis was made of composite medical departments. A sample of these patients was later followed up at 3 months and again at 2 years (Ferguson and MacPhail, 1954) to ascertain their ultimate disposal.

The Birmingham Regional Hospital Board has recently reviewed hospital morbidity in part of their regional area (Cross, 1957). The method adopted was similar to that followed in the present survey, except that the analysis was based on discharges instead of on admissions. The study was confined to three

separate areas (comprising an administrative county, a large county borough, and a group of local authority areas) and the sex-age-specific discharge rates were derived for each area separately for different diagnoses. Some important differences were found between the mainly rural administrative area and the highly industrialized county borough which were considered to be worthy of further inquiry.

The numbers discharged by specialty from hospitals in England and Wales are collected and published annually by the Ministry of Health. From these figures overall discharge rates for the various specialties can be calculated for the country, but no account is taken of age or sex (Ministry of Health, 1950–57, 1957).

Present Survey

The material on which the present paper is based was obtained during an inquiry into the size of population served by a group of hospitals located in the Reading County Borough (Barr and Davies, 1957). An area surrounding the county borough was selected (see Fig. 1) and the total number of hospital

Key to Fig. 1		Registrar General's Estimated Population (June 30, 1955)
1	Reading C.B.	118,100
2	Abingdon M.B.	12,140
3	Aldershot M.B.	40,190
4	Basingstoke M.B.	19,610
5	Henley-on-Thames M.B.	8,010
6	High Wycombe M.B.	42,800
7	Maidenhead M.B.	28,600
8	Marlborough M.B.	5,430
9	Newbury M.B.	18,540
10	Wallingford M.B.	3,740
11	Wokingham M.B.	9,370
12	Farnborough U.D.	28,260
13	Fleet U.D.	9,560
14	Marlow U.D.	6,710
15	Thame U.D.	3,710
16	Wantage U.D.	5,560
17	Abingdon R.D.	25,390
18	Basingstoke R.D.	17,340
19	Bradfield R.D.	22,250
20	Bullingdon R.D.	38,770
21	Cookham R.D.	15,090
22	Easthampstead R.D.	30,230
23	Hartley Wintney R.D.	25,220
24	Henley R.D.	20,450
25	High Wycombe R.D.	42,910
26	Hungerford R.D.	9,860
27	Kingsclere & Whitchurch R.D.	19,180
28	Marlborough & Ramsbury R.D.	10,330
29	Newbury R.D.	19,930
30	Wallingford R.D.	16,610
31	Wantage R.D.	15,030
32	Wokingham R.D.	41,430

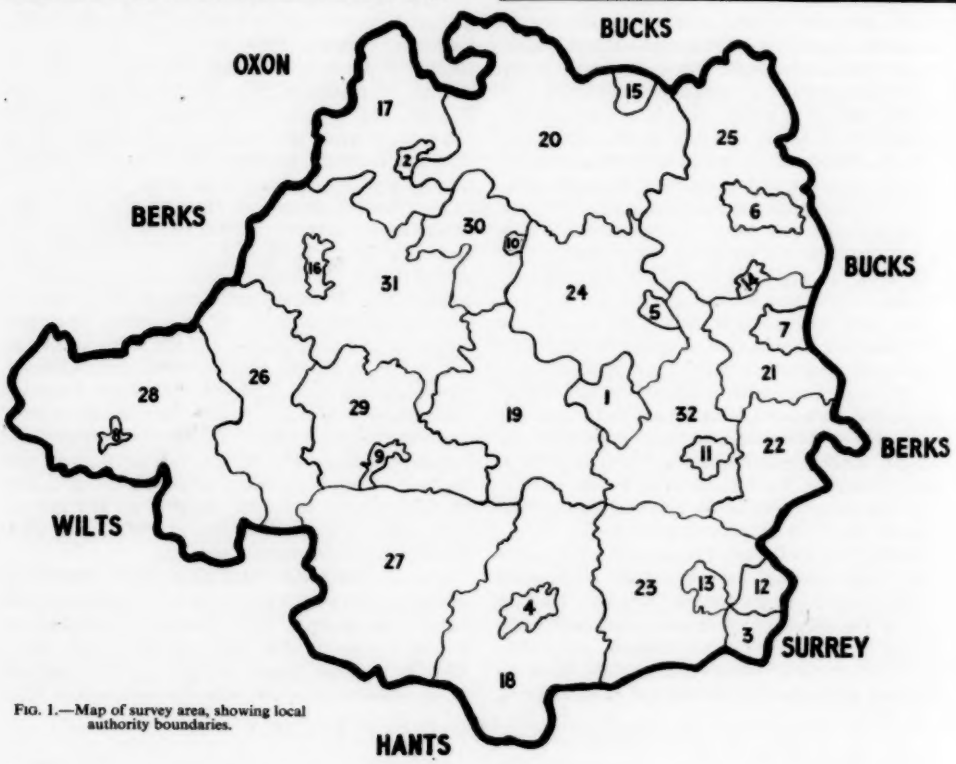

Fig. 1.—Map of survey area, showing local authority boundaries.

admissions of persons resident in this area was found by reference to hospitals inside and outside the area. Those participating included hospitals in the North-West and South-West Metropolitan Regional Hospital Boards and several private nursing homes, in addition to the United Oxford Hospitals and hospitals of the Oxford Regional Hospital Board. Altogether, 77 hospitals took part in the inquiry. A supplementary inquiry sent to general practitioners living in the survey area showed that there were a few patients (estimated at between thirty and forty) who were resident in the area but received treatment outside the hospitals surveyed. These consisted mainly of neurosurgical and orthopaedic cases for whom special facilities exist at Oxford. The number involved was small and therefore unlikely to affect the general results.

Each hospital was asked to supply on a proforma the address, sex, age, and department (medicine, surgery, traumatic and orthopaedic surgery, E.N.T. surgery, gynaecology, and obstetrics) of all patients admitted from the selected area during the months of April and May, 1956. This information was subsequently coded and transferred to punch cards. Although the basic material was simple, the results have been of value and, as Bailey (1956) suggests, work of this kind is worth repeating.

The term "admission" in this paper relates to new admissions staying for one night or more; day admissions and inter-hospital transfers have been excluded.

Area Surveyed

Population.—The total number of persons in the selected area, according to the 1951 Census, was 672,800 (336,300 males, 336,500 females). The largest centre of population was Reading County Borough (Area 1) with 114,200, the only county borough in the area. In addition, there were ten municipal boroughs, five urban districts, and sixteen rural districts spread over five counties (Berkshire, Buckinghamshire, Hampshire, Oxfordshire, and Wiltshire). Next in size to Reading were High Wycombe Municipal Borough (Area 6) with 40,700, High Wycombe Rural District (Area 25) with 39,400, Aldershot Municipal Borough (Area 3) with 37,600, and Bullingdon Rural District (Area 20) with 35,000. Apart from Aldershot M.B. (Area 3) and Farnborough U.D. (Area 12), the absolute numerical size of the population in each age group did not vary greatly between the sexes. To the presence of the military camp and R.A.F. station at Aldershot (Area 3) and of the aircraft research unit at Farnborough (Area 12) was due an excess of young men between 15 and 30 years of age. A reliable estimate of the actual number involved by age could not be obtained, and hence it was not possible to exclude them from the estimated population at risk.

Size.—The area included some 940,000 acres or 1,470 square miles, the largest administrative areas being Marlborough and Ramsbury Rural District (Area 28) with 94,510 acres and Bullingdon Rural District (Area 20) with 90,541, and the smallest Wallingford Municipal Borough (Area 10) with 760 acres. The density of population ranged from 12·5 persons per acre in Reading County Borough (Area 1) to 0·12 in Marlborough and Ramsbury Rural District (Area 28).

Results

The geographical distribution of the hospital admissions by specialty and sex is given in Table I. The greatest number of male patients was admitted for surgery while the gynaecological and obstetrical departments admitted the greatest number of female patients. The admission rates for the various specialties show some interesting differences between the administrative areas. It will be seen, for instance, that in all the rural districts except one (Bradfield R.D., Area 19), the male hospital admission rate exceeds the female in surgery. Similarly, in traumatic and orthopaedic surgery, eleven of the sixteen rural districts have a higher male rate. In other specialties and types of area the ratio of male to female patients seems to follow no consistent pattern. For both sexes, in both medicine and surgery, the minimum and the maximum admission rates are lower in rural districts than in the county borough, municipal boroughs, and urban districts, and the maximum rates for traumatic and orthopaedic surgery and E.N.T. surgery are also lowest in the rural district. The female rates for medicine appeared to have a greater range than the male, whereas the reverse is true in E.N.T. surgery and to a lesser extent in surgery. In gynaecology and obstetrics, the maximum and minimum admission rates are higher in the municipal boroughs (including the county borough) than in other types of areas. The admission rate for obstetrics is remarkably high in Abingdon Municipal Borough (Area 2).

GEOGRAPHICAL DISTRIBUTION OF HOSP
AVERAGE NUMBER OF CASES AND RATE PER 1,000 PER MO

Administrative Area	Area Code (see Fig. 1)	MALE							
		Medicine		Surgery		Traumatic and Orthopaedic Surgery		E.N.T. Surgery	
		No.	Rate	No.	Rate	No.	Rate	No.	Rate
County Borough	1	37·5	0·69	100·0	1·85	49·0	0·91	34·5	0·64
Municipal Boroughs ..	2	12·0	2·45	12·0	2·46	4·5	0·92	6·5	1·33
	3	15·0	0·67	25·5	1·14	—	—	11·5	0·51
	4	22·5	2·76	19·5	2·39	4·0	0·49	13·5	1·66
	5	6·0	1·64	9·5	2·59	3·0	0·82	4·0	1·09
	6	24·0	1·22	33·0	1·68	22·0	1·12	26·0	1·32
	7	23·0	1·83	34·0	2·71	13·5	1·07	4·5	0·36
	8	5·0	2·34	3·0	1·40	3·5	1·64	0·5	0·23
	9	9·0	1·08	18·5	2·23	3·5	0·42	13·0	1·57
	10	2·0	1·21	4·0	2·42	1·5	0·91	—	—
	11	3·0	0·77	12·5	3·19	5·0	0·13	5·0	1·28
Urban Districts	12	11·0	0·73	16·5	1·10	0·5	0·33	14·0	0·93
	13	3·5	0·80	11·5	2·64	2·0	0·46	4·0	0·92
	14	3·0	0·99	3·5	1·15	3·5	1·16	1·0	0·33
	15	3·0	1·76	7·0	4·09	2·0	1·17	3·5	2·05
	16	5·5	2·38	9·5	4·11	1·5	0·65	6·0	2·59
All Municipal Boroughs and Urban Districts		147·5	1·29	219·5	1·93	70·0	0·62	113·0	0·99
Rural Districts	17	13·0	1·07	8·0	0·66	3·0	0·25	7·0	0·57
	18	8·0	0·92	12·5	1·45	1·0	0·12	4·5	0·52
	19	8·0	0·89	15·5	1·73	7·0	0·78	4·5	0·50
	20	5·5	0·31	11·5	0·64	4·5	0·25	6·0	0·34
	21	3·5	0·52	6·5	0·97	2·0	0·30	4·5	0·67
	22	8·0	0·66	21·5	1·78	6·0	0·50	8·0	0·66
	23	8·5	0·69	9·5	0·77	2·0	0·16	7·0	0·56
	24	5·5	0·57	13·5	1·39	3·0	0·31	6·0	0·62
	25	13·5	0·70	25·5	1·32	11·5	0·59	12·5	0·65
	26	9·0	1·91	9·0	1·91	3·0	0·64	4·0	0·85
	27	5·5	0·59	12·0	1·28	2·5	0·27	8·0	0·85
	28	6·0	1·01	9·0	1·51	4·5	0·75	2·0	0·33
	29	5·0	0·72	11·5	1·66	5·5	0·79	8·5	1·22
	30	5·0	0·64	11·0	1·42	6·0	0·77	10·5	1·35
	31	6·5	0·87	10·0	1·34	3·0	0·40	6·0	0·80
	32	11·0	0·60	28·0	1·53	18·0	0·98	13·5	0·74
All Rural Districts		121·5	0·73	214·5	1·27	82·5	0·49	112·5	0·67
All Areas		306·5	0·91	534·0	1·59	201·5	0·60	260·0	0·77

Like the hospital admission rate for all ages combined, the admission rate for specific ages differs between areas, but the numbers are too small to permit a detailed analysis by individual areas. Instead, in Table II (opposite) and Fig. 2 (overleaf), a comparison is made between specific sex and age groups in the aggregate urban districts (including the county borough and municipal boroughs) and the aggregate rural areas.

The urban (county borough + municipal boroughs + urban districts) admission rates exceed the rural in every age group and both sexes for medicine (except females aged 30–44), surgery, traumatic and orthopaedic surgery (except females aged 75+), gynaecology, and obstetrics. This is also true of E.N.T. surgery, except in the age groups where the rates are negligible. If, however, the rates for the county borough alone are compared with the rural rates, then in quite a few instances the age-specific rates for the rural areas exceed those for the town. There is a consistent upward trend in admission rates with age in both sexes and all types of districts, and in males for surgery in all types of districts. But the age trends are much less definite for surgery in females; in urban districts, the age distribution of the female surgical rates is bimodal in character. On the other hand, there is little association between age and admission in traumatic and orthopaedic surgery. The E.N.T. surgery admissions, as would be expected, reached a peak in children (*i.e.* persons under 15 years of age) after which there is a steep decline.

In Table III (overleaf, p. 68), the admission rates have been standardized by the method used in obtaining Standardized Mortality Ratios (S.M.R.). For each sex and specialty, the age-specific admission

ISSIONS BY SPECIALTY AND SEX
ED ON 2-MONTH SURVEY PERIOD (APRIL AND MAY, 1956)

FEMALE

Medicine		Surgery		Traumatic and Orthopaedic Surgery		E.N.T. Surgery		Gynaecology		Obstetrics	
No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
38·0	0·63	71·0	1·18	24·5	0·41	40·5	0·67	74·0	1·23	98·0	1·63
12·0	2·27	16·5	3·12	4·0	0·76	5·5	1·04	9·0	1·70	29·5	5·58
24·0	0·92	16·5	1·08	1·5	0·10	13·0	0·85	15·0	0·98	23·5	1·54
39·5	2·21	17·0	1·93	2·5	0·28	11·0	1·25	15·5	1·76	32·0	3·63
7·5	1·74	7·0	1·62	5·5	1·27	4·5	1·04	4·5	1·04	11·0	2·55
20·5	0·98	29·5	1·40	17·0	0·81	26·0	1·24	26·0	1·24	46·0	2·19
18·5	1·27	21·5	1·47	9·5	0·75	6·0	0·41	29·5	2·02	31·5	2·16
7·0	2·89	5·0	2·07	2·0	0·83	—	—	2·5	1·03	7·0	2·89
21·0	1·16	18·5	1·95	6·0	0·63	13·5	1·42	12·0	1·27	20·0	2·11
1·0	1·07	5·5	2·95	2·0	1·07	1·5	0·81	3·0	1·61	3·0	1·61
2·0	—	—	—	—	—	—	—	—	—	—	—
2·0	0·42	8·0	1·66	6·0	1·25	7·0	1·46	5·5	1·14	14·5	3·02
9·5	0·93	18·0	0·85	1·61	—	—	11·0	0·98	4·5	0·40	27·0	2·41
10·5	0·92	5·0	2·25	1·07	2·5	0·54	4·5	0·96	5·5	1·18	5·0	1·07
8·0	0·31	5·0	2·32	1·45	1·5	0·44	4·5	1·30	3·0	0·87	4·5	1·30
7·0	2·05	5·5	3·73	2·93	1·5	0·80	2·0	1·07	0·5	0·27	1·5	0·80
4·5	2·59	6·5	1·62	2·34	1·0	0·36	3·0	1·08	2·5	0·90	5·5	1·98
53·5	0·99	185·0	1·37	65·5	0·56	113·0	1·01	138·5	1·24	261·5	2·34
5·0	0·57	6·5	0·44	0·58	2·5	0·22	7·5	0·67	10·5	0·93	19·0	1·69
10·0	0·52	9·5	1·20	1·14	3·0	0·36	6·0	0·72	6·0	0·72	20·0	2·40
9·5	0·50	19·5	0·96	1·96	6·5	0·66	8·0	0·81	9·5	0·96	19·0	1·91
8·5	0·34	9·0	0·50	0·53	3·0	0·18	7·5	0·44	8·0	0·47	11·5	0·67
5·5	0·67	6·5	0·76	0·90	2·0	0·28	2·5	0·35	5·5	0·76	11·0	1·52
8·0	0·66	20·0	0·70	1·76	8·5	0·75	9·0	0·79	12·0	1·06	21·5	1·89
12·5	0·58	5·5	1·21	0·53	4·5	0·44	8·0	0·78	10·0	0·97	16·0	1·55
7·5	0·62	10·5	0·73	1·02	5·0	0·48	5·5	0·53	7·5	0·73	17·5	1·70
19·5	0·65	25·0	0·97	1·25	9·5	0·47	18·0	0·90	17·0	0·85	23·0	1·15
2·5	0·85	6·5	0·53	1·38	0·5	0·11	4·0	0·85	3·5	0·74	7·0	1·49
8·0	0·85	9·0	0·87	0·98	2·5	0·27	5·0	0·55	10·0	1·09	10·0	1·09
10·5	0·33	7·5	2·08	1·49	2·0	0·40	1·5	0·30	3·5	0·69	13·0	2·58
8·0	1·22	9·0	1·11	1·25	3·0	0·42	9·0	1·25	6·5	0·90	17·0	2·36
2·5	1·35	9·5	0·32	1·21	1·5	0·19	5·5	0·70	6·5	0·83	12·0	1·53
4·0	0·80	7·5	0·56	1·06	2·0	0·28	5·5	0·78	6·5	0·91	10·5	1·48
13·5	0·74	21·0	0·76	1·19	9·5	0·54	9·0	0·51	21·5	1·22	31·5	1·79
35·0	0·67	182·0	0·82	1·11	65·5	0·40	111·5	0·68	144·0	0·88	259·5	1·58
26·5	0·77	438·0	0·97	1·30	152·5	0·45	265·0	0·79	356·5	1·06	619·0	1·84

TABLE II

ERAGE MONTHLY NUMBER OF ADMISSIONS TO HOSPITAL, AND HOSPITAL ADMISSION RATE PER 1,000 PER MONTH OF THE PULATION IN COUNTY BOROUGH, AGGREGATE URBAN DISTRICTS (INCLUDING MUNICIPAL BOROUGHS), AND THE AGGREGATE RURAL DISTRICTS, BY SPECIALTY, AGE, AND SEX
BASED ON 2-MONTH SURVEY PERIOD, APRIL AND MAY, 1956

Specialty		Area	Age Group (yrs) and Sex															
			0–		15–		30–		45–		60–		75+		Not Stated		All Ages	
			Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
umber f Ad- ssions	Medicine	C.B.	—	1·5	5·0	3·5	5·5	6·5	11·5	12·0	11·0	11·0	4·0	3·5	0·5	—	37·5	38·0
		U.D.	8·0	9·5	12·5	17·5	21·5	15·0	44·5	38·5	41·5	41·0	18·5	30·0	1·0	2·0	147·5	153·5
		R.D.	4·0	3·0	14·0	15·5	14·5	23·0	35·0	29·0	37·0	44·0	15·5	19·0	1·5	1·5	121·5	135·0
		All Areas	12·0	14·0	31·5	36·5	41·5	44·5	91·0	79·5	89·5	96·0	38·0	52·5	3·0	3·5	306·5	326·5
	Surgery	C.B.	2·5	1·5	11·0	20·5	23·0	17·5	28·0	14·0	22·5	13·5	13·0	4·0	—	—	100·0	71·0
		U.D.	35·5	17·5	27·0	37·5	50·0	39·5	53·5	34·0	39·5	36·5	13·0	19·0	1·0	1·0	219·5	185·0
		R.D.	22·0	17·5	28·0	30·5	44·0	45·0	54·5	39·0	45·0	33·0	20·0	15·0	1·0	2·0	214·5	182·0
		All Areas	60·0	36·5	66·0	88·5	117·0	102·0	136·0	87·0	107·0	83·0	46·0	38·0	2·0	3·0	534·0	438·0

—continued

TABLE II (*continued*)

Specialty		Area	Age Group (yrs) and Sex															
			0–		15–		30–		45–		60–		75+		Not Stated		All Ages	
			Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Number of Admissions (*contin.*)	Traumatic and Orthopaedic Surgery	C.B.	16·0	7·5	12·0	4·0	10·5	2·5	6·5	4·5	2·0	5·0	1·0	1·0	1·0	—	49·0	24·5
		U.D.	15·5	10·5	16·0	11·5	9·0	10·5	15·5	13·0	9·5	9·5	4·0	6·5	0·5	1·0	70·0	62·5
		R.D.	19·5	12·5	22·0	9·5	14·5	9·5	15·5	15·0	5·5	9·5	3·0	7·5	2·5	2·0	82·5	65·5
		All Areas	51·0	30·5	50·0	25·0	34·0	22·5	37·5	32·5	17·0	24·0	8·0	15·0	4·0	3·0	201·5	152·5
	Ear, Nose, and Throat Surgery	C.B.	23·0	30·5	3·0	5·5	2·5	0·5	3·0	2·5	2·0	1·0	1·0	—	0·5	—	35·0	40·0
		U.D.	85·0	85·0	6·5	13·0	8·0	5·5	6·5	2·0	1·5	3·0	1·5	—	4·0	4·5	113·0	113·0
		R.D.	69·5	70·5	7·0	14·0	9·5	11·0	10·5	5·5	5·5	3·5	1·5	1·0	8·5	6·5	112·0	112·5
		All Areas	177·5	186·0	16·5	32·5	20·0	17·0	20·0	10·0	9·0	7·5	4·0	1·0	13·0	11·0	260·0	265·0
	Gynaecology	C.B.	—	—	—	15·5	—	29·5	—	22·5	—	4·5	—	1·5	—	0·5	—	74·0
		U.D.	—	—	—	37·5	—	46·5	—	40·0	—	11·5	—	2·5	—	0·5	—	138·5
		R.D.	—	—	—	29·0	—	58·0	—	41·0	—	13·0	—	1·5	—	1·5	—	144·0
		All Areas	—	—	—	82·0	—	134·0	—	103·5	—	29·0	—	5·5	—.	2·5	—	356·5
	Obstetrics	C.B.	—	—	—	64·5	—	33·5	—	—	—	—	—	—	—	—	—	98·0
		U.D.	—	—	—	182·5	—	77·5	—	1·0	—	—	—	—	—	0·5	—	261·5
		R.D.	—	—	—	179·0	—	78·5	—	0·5	—	—	—	—	—	1·5	—	259·5
		All Areas	—	—	—	426·0	—	189·5	—	1·5	—	—	—	—	—	2·0	—	619·0
Admission Rate per 1,000 Population	Medicine	C.B.	—	0·12	0·46	0·30	0·46	0·50	1·12	1·01	1·77	1·31	2·30	1·17	—	—	0·69	0·63
		U.D.	0·33	0·41	0·39	0·77	0·90	0·61	2·32	1·82	3·75	2·78	5·80	5·62	—	—	1·30	1·37
		R.D.	0·11	0·08	0·33	0·48	0·40	0·64	1·21	0·95	2·05	1·99	2·85	2·45	—	—	0·72	0·82
		All Areas	0·16	0·20	0·37	0·54	0·58	0·61	1·56	1·25	2·53	2·12	3·67	3·27	—	—	0·91	0·97
	Surgery	C.B.	0·19	0·12	1·01	1·75	1·91	1·36	2·74	1·18	3·61	1·60	7·48	1·34	—	—	1·85	1·18
		U.D.	1·44	0·75	0·85	1·65	2·09	1·61	2·79	1·61	3·57	2·47	4·07	3·56	—	—	1·93	1·65
		R.D.	0·59	0·49	0·66	0·94	1·22	1·25	1·89	1·28	2·49	1·49	3·68	1·94	—	—	1·27	1·11
		All Areas	0·80	0·51	0·77	1·32	1·62	1·39	2·34	1·37	3·03	1·83	4·44	2·36	—	—	1·59	1·30
	Traumatic and Orthopaedic Surgery	C.B.	1·24	0·61	1·11	0·34	0·87	0·19	0·64	0·38	0·32	0·59	0·58	0·33	—	—	0·90	0·41
		U.D.	0·63	0·45	0·50	0·50	0·38	0·43	0·81	0·62	0·86	0·64	1·25	1·22	—	—	0·62	0·56
		R.D.	0·52	0·35	0·52	0·29	0·40	0·26	0·54	0·49	0·30	0·43	0·55	0·97	—	—	0·49	0·40
		All Areas	0·68	0·43	0·59	0·37	0·47	0·31	0·64	0·51	0·48	0·53	0·77	0·93	—	—	0·60	0·45
	Ear, Nose, and Throat Surgery	C.B.	1·78	2·48	0·28	0·47	0·21	0·04	0·29	0·21	0·32	0·12	0·57	—	—	—	0·64	0·67
		U.D.	3·45	3·63	0·20	0·57	0·33	0·22	0·34	0·09	0·14	0·20	0·47	—	—	—	0·99	1·01
		R.D.	1·86	1·98	0·16	0·43	0·26	0·31	0·36	0·18	0·30	0·16	0·28	0·13	—	—	0·67	0·68
		All Areas	2·37	2·61	0·19	0·49	0·28	0·23	0·34	0·16	0·25	0·17	0·39	0·60	—	—	0·77	0·79
	Gynaecology	C.B.	—	—	—	1·32	—	2·28	—	1·90	—	0·53	—	0·50	—	—	—	1·23
		U.D.	—	—	—	1·65	—	1·90	—	1·90	—	0·78	—	0·47	—	—	—	1·24
		R.D.	—	—	—	0·89	—	1·61	—	1·35	—	0·59	—	0·19	—	—	—	0·88
		All Areas	—	—	—	1·22	—	1·82	—	1·63	—	0·64	—	0·34	—	—	—	1·06
	Obstetrics	C.B.	—	—	—	5·50	—	2·59	—	—	—	—	—	—	—	—	—	1·63
		U.D.	—	—	—	8·02	—	3·17	—	0·05	—	—	—	—	—	—	—	2·34
		R.D.	—	—	—	5·51	—	2·18	—	0·02	—	—	—	—	—	—	—	1·58
		All Areas	—	—	—	6·36	—	2·58	—	0·02	—	—	—	—	—	—	—	1·84

rate of the total area surveyed was applied to the corresponding age-specific population of each administrative area, thereby giving the expected number of admissions which would have occurred had each area experienced the same series of age specific admission rates. The ratio per cent. of the total observed or actual admissions to total expected admissions in each area gives the standardized

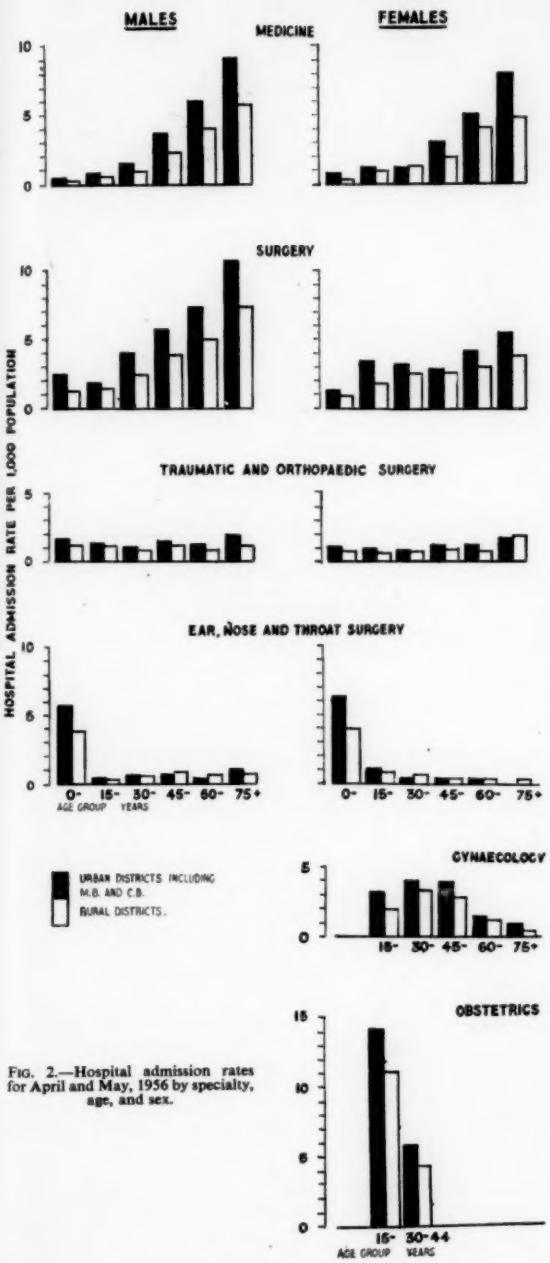

FIG. 2.—Hospital admission rates for April and May, 1956 by specialty, age, and sex.

ratio for the area. The standard error of this ratio can be taken as $100\sqrt{O}/E$ where O denotes the number of hospital admissions observed and E the number expected. Differences from 100 per cent. which are greater than twice the standard error (*i.e.* roughly equivalent to the 5 per cent. probability level) may be taken as significant and are shown in the Table in bold type. Theoretically, the standard error is subject to a small error due to the possible admission of a patient more than once, but in a 2-month period this is unlikely to happen often and can be ignored.

It will be seen that the standardized admission ratios fluctuate considerably between local authority areas. This may be partly due to the small numbers, involved but this alone does not fully explain the differences. For instance, at Basingstoke Municipal Borough (Area 4), where there were 45 medical admissions, the standardized ratio was 28·5 per cent., compared with 73 per cent in Reading County Borough (Area 1). Or again, for male surgical admissions, the ratio in Maidenhead Municipal Borough (Area 7) was 162 per cent. based on 68 admissions compared with 113 per cent. in Reading (Area 1) based on 200 admissions, or 102 per cent. in High Wycombe Municipal Borough (Area 6) based on 66 admissions.

The product-moment correlation coefficients derived from the standardized admission ratios (Table IV, overleaf) show some important tendencies. First, there is a highly significant correlation between the male and female standardized ratios in each of the four specialties considered (see cells in Table outlined with heavy lines). Secondly, medical admissions are highly correlated with surgical admissions but not with the other surgical specialties, with two minor exceptions. Thirdly, male and female surgical admissions give significant correlations with other sex-specialty groups, except in the case of female surgery and female E.N.T. surgery. Fourthly, there is little correlation between the standardized ratios for traumatic and orthopaedic surgery and E.N.T. surgery.

TABLE III

AGE STANDARDIZED ADMISSION RATIOS BY SPECIALTY AND SEX (RATIOS DIFFERING SIGNIFICANTLY FROM 100 PER CENT IN BOLD TYPE)

Administrative Area	Area Code No. (see Fig. 1)	Specialty and Sex									
		Medicine		Surgery		Traumatic and Orthopaedic Surgery		E.N.T. Surgery		Gynaecology	Obstetrics
		Male	Female	Male	Female	Male	Female	Male	Female	Female	Female
County Boroughs	1	**73**	**64**	113	91	**154**	91	82	92	116	91
Municipal Boroughs	2	**275**	**242**	155	**244**	155	174	163	136	161	303
	3	99	109	89	87	—	**23**	87	109	92	**72**
	4	**285**	**232**	142	150	85	63	**218**	171	**165**	**199**
	5	154	158	151	119	136	**268**	154	164	99	155
	6	**132**	106	102	110	**191**	**185**	**177**	**165**	114	114
	7	**189**	125	**162**	111	**182**	144	**48**	**58**	**189**	118
	8	238	**286**	83	161	304	190	30	—	98	171
	9	108	114	131	147	72	140	**205**	**216**	121	120
	10	125	98	140	211	150	235	—	115	158	90
	11	70	**37**	**176**	123	213	**255**	169	203	113	199
Urban Districts	12	105	99	83	130	**6**	—	139	118	**38**	121
	13	82	**208**	161	80	80	116	127	134	115	66
	14	103	**246**	70	111	194	94	44	170	83	73
	15	182	**389**	**241**	224	190	167	269	143	26	**45**
	16	**282**	164	**260**	181	111	80	**308**	143	89	112
Rural Districts	17	131	**52**	**44**	**46**	**42**	42	76	79	89	88
	18	94	117	87	86	**20**	78	74	101	69	140
	19	88	97	102	**150**	133	146	67	114	89	102
	20	**37**	**57**	**43**	**43**	**43**	**41**	**43**	**52**	**46**	**35**
	21	57	79	**60**	69	51	63	83	**47**	71	82
	22	72	72	111	136	86	167	95	102	101	108
	23	85	125	**54**	**41**	**27**	98	89	96	96	87
	24	**59**	75	84	78	**52**	110	83	75	68	93
	25	75	102	81	97	101	107	84	119	81	**63**
	26	**196**	54	115	107	109	**23**	110	107	73	85
	27	**61**	93	78	77	**46**	62	118	70	106	**60**
	28	112	**214**	97	116	129	89	**46**	**38**	68	148
	29	73	110	99	95	138	92	163	157	86	134
	30	70	**34**	89	95	132	**43**	**188**	90	80	84
	31	96	65	84	83	69	65	107	91	88	77
	32	**66**	78	97	91	**167**	121	104	68	115	101
All Areas		100	100	100	100	100	100	100	100	100	100

TABLE IV

CORRELATION CO-EFFICIENTS (r) BETWEEN THE STANDARDIZED ADMISSION RATIOS IN FOUR SPECIALTIES IN 32 ADMINISTRATIVE AREAS

Variables Correlated		Medicine		Surgery		Traumatic and Orthopaedic Surgery		Ear, Nose, and Throat Surgery	
		Male	Female	Male	Female	Male	Female	Male	Female
Medicine	Male		+0·58***	+0·57***	+0·66***	+0·35	+0·16	+0·41*	+0·15
	Female			+0·45*	+0·58**	+0·41*	+0·25	+0·25	+0·11
Surgery	Male				+0·69***	+0·37*	+0·44*	+0·67***	+0·47*
	Female					+0·49**	+0·50**	+0·37*	+0·33
Traumatic and Orthopaedic Surgery	Male						+0·64***	+0·03	+0·06
	Female							+0·03	+0·31
Ear, Nose, and Throat Surgery	Male								+0·60***
	Female								

* Significant at 5 per cent. ** Significant at 1 per cent. *** Significant at 0·1 per cent.

Discussion

A study of this kind can have several important applications. First, it is obvious that an accurate assessment of illness should lead to the best use being made of the treatment facilities available. Secondly, such information should provide a more realistic basis for the planning of future hospital developments both as to the number of beds required and where they should be located. Thirdly, the analysis of cost in terms of population served may give a better yardstick for comparing the volume of hospital work and a more equitable basis for the allocation of exchequer grants. Fourthly, an epidemiological study of sickness against its sociological background may throw some light on how far illness can be prevented.

The present analysis is rather limited in scope, the data having been obtained as a secondary product of another inquiry. Nevertheless, it serves to illustrate the kind of approach to hospital sickness which might be developed and carried out to advantage in different regional areas. In a future paper it is hoped to examine the hospital admission rates given in this paper in relation to certain social indices.

It would obviously have been desirable to have used diagnosis rather than specialty, but for the reason already given this information was not obtained. The introduction of diagnosis would have entailed the collection of a much larger series of cases before analysis could have been undertaken. In a relatively small and compact area like that under study, the grouping of cases by specialties has no serious disadvantages, provided a common standard is applied. In this survey the patient was classified according to specialty at the time of admission to hospital. Inevitably, there were a number of patients who were admitted, for example, as medical cases and later transferred and ultimately discharged from a surgical ward. Such patients were regarded as medical. The numbers thus involved were probably small and do not distort the general picture. In any wider comparison, say between one part of the country and another, it would be essential to use diagnoses because of the differences in the groups of diseases covered by specialists in different areas. The national survey of hospital patients (H.I.P.E.) should provide the kind of information required.

It is clear that there are wide differences between administrative areas in the pattern of sickness. The Nuffield Provincial Hospitals Trust (1955) showed in their investigation of the demand for hospital beds in 1951 that the hospital admission rates varied considerably; for instance, in the catchment area of the General Hospital at Northampton, the admission rates were as high as 103 per 1,000 in the Bletchley Urban District and as low as 16 per 1,000 in Raunds Urban District. In the Norfolk and Norwich areas the rates varied roughly between 10 and 104 per 1,000 of the population. In the urban districts 52 people out of every 1,000 were admitted and only 31 per 1,000 in the rural areas. The Trust concluded that "if a difference in the admission rates for urban and rural areas were to be confirmed by similar data from other parts of the country, it would then be an important consideration to be taken into account when assessing the hospital needs of a community".

The present survey provides further examples of the difference in the hospital admission rates. Generally, the rate in the county borough and urban districts was above that for rural areas, and this applied in most age groups (Fig. 2). No adequate explanation can be given at the moment for the age and geographical differences, but this is a problem which is worth investigating, since it not only influences future planning of the hospital services but also affects the current cost of the health service.

The product-moment correlations suggest either that some areas are more prone to hospital sickness than others or that doctors in different areas make varying demands upon the hospital service. For instance, the standardized admission ratio for men in Thame Urban District (population 3,600) ranked seventh in medicine (out of 32 areas), second in surgery, fifth in traumatic and orthopaedic surgery, and second in E.N.T. surgery. Again, in Abingdon Municipal Borough (population 10,000), the standardized male admission ratio ranked third for medicine, sixth for surgery, eighth for traumatic and orthopaedic surgery, and eighth for E.N.T. surgery. The corresponding female admission ratio ranked fourth for medicine, first for surgery, sixth for traumatic and orthopaedic surgery, tenth for E.N.T. surgery, fourth for gynaecology, and first for obstetrics. At the other end of the scale, in Bullingdon Rural District (population 35,000), the standardized male admission ratio ranked last for medicine, last for surgery, 27th for traumatic and orthopaedic surgery, and 30th for E.N.T. surgery, while the female admission ratio ranked 28th for medicine, last for surgery, 29th for traumatic and orthopaedic surgery, 28th for E.N.T. surgery, 31st for gynaecology, and last for obstetrics. It would be interesting to discover the exact reasons for such dissimilarities.

Summary

(1) The hospital admissions in a defined area during April and May, 1956 have been analysed.

(2) The admission rate varied considerably between areas.

(3) Among men, medical cases occurred largely in the older age groups, surgical cases in middle life, and traumatic and orthopaedic cases in younger adults. The trend was similar for women, except that the peak in medical cases occurred in the older age groups and that for surgical cases in younger age groups.

(4) The hospital admission rate was generally higher in the urban (including municipal and county boroughs) areas than in the rural areas, with the exception of traumatic and orthopaedic admissions.

(5) The hospital admission rate increased with age in medicine and surgery. In traumatic and orthopaedic surgery, there was little difference between the age groups, and in E.N.T. surgery the peak rate occurred in children under 15 years of age. The gynaecological admission rate remained fairly static until 60 years and thereafter declined.

(6) There was good agreement between the standardized admission ratios for males and females in the 32 administrative areas in each of the four specialties of medicine, surgery, traumatic and orthopaedic surgery, and E.N.T. surgery. The surgical admission ratio for males and females correlated significantly with each of the other sex-specialty ratios, with one exception. Medical admissions showed agreement with surgical admissions, with only two exceptions. There was no agreement between the ratios for traumatic and orthopaedic surgery and E.N.T. surgery.

This analysis would not have been possible without the kind cooperation of the staff at the various hospitals and nursing homes providing the basic information. I am grateful to my colleagues at the Regional Board for valuable assistance. I am particularly indebted to Dr. E. A. Cheeseman, of the Department of Social and Preventive Medicine, the Queen's University, Belfast, for considerable help and advice in the preparation of this paper. The survey was carried out under the aegis of the Oxford Regional Hospital Board.

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INCIDENCE OF GASTRIC AND DUODENAL ULCER IN THE BRITISH ARMY IN 1955

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No estimate of the prevalence of gastric and duodenal ulcer is entirely satisfactory. It has been generally felt however that there has been a great increase in the incidence of duodenal ulcer in the last three decades. In the first world war up to the end of 1915 (*i.e.* in 16 months), there were 109 medical discharges from the Army for "inflammation and ulceration of the stomach". In World War II up to the end of 1941 (*i.e.* in 28 months), there were 23,574 (Tidy, 1943).

Doll (1952) has reviewed the methods available for determining the true incidence of peptic ulceration in the community at large. National mortality statistics are unsatisfactory because the disease has a low fatality rate. Selection factors vary enormously in various hospital services. He concluded that a population survey is the method of choice if the group chosen is typical of the population, and Doll, Jones, and Buckatzsch (1951) made such a survey, mainly in London.

Individual medical documents are available for the whole British Army, which emphasises a suitably large population, and we have analysed the morbidity from peptic ulcer diagnosed for the first time in 1955 in male personnel.

METHOD

Copies of summaries of the medical histories of hospital in-patients for the entire British Army are available centrally, and particulars of all admissions to hospital are coded on punch cards under a number of headings.

In 1955 diagnoses of gastric, duodenal, or peptic ulceration were made in 1,203 Army personnel.

The medical documents could not be traced in fourteen cases, but each of the remaining 1,189 (98·8 per cent.) was examined. 197 were excluded because: the diagnosis had first been made before 1955 (185 patients); the patient was a female (9); there had been errors of coding (3).

The remaining 992 male servicemen were admitted to hospital in 1955 for the first time with a diagnosis of peptic ulcer. In 138 patients the diagnosis was presumptive, either because they had not had a barium meal (40) or because the results were negative (98). For the purpose of the survey the remaining 854 patients were considered to have had ulcers proven.

The criteria of proven diagnosis adopted were as follows:

(1) 664 duodenal and eighty gastric ulcers were demonstrated by barium meal to the satisfaction of the radiologist concerned, as were three ulcers of which the site was not stated. Eight patients had both gastric and duodenal ulcers. Clearly the diagnostic criteria vary between different radiologists. Doll and others (1951) wrote concerning a similar situation in their survey:

"The larger number of radiologists concerned introduces a random element which, in the absence of a single uniform opinion, is the best safeguard against bias in favour of any one group".

(2) 85 duodenal, fourteen gastric, and two ulcers with site not specified were found at laparotomy to have perforated.

(3) Two duodenal ulcers were found at laparotomy for haematemesis.

(4) Eight duodenal and six gastric ulcers were found at elective gastric surgery.

(5) Neither gastroscopy nor autopsy contributed cases to this series.

In some cases the diagnosis was established by more than one method in the course of the year, and therefore the totals of the above groups add up to more than the total 854 patients.

All ulcers were classified by us as either duodenal or gastric. Ten patients had ulcers of both stomach and duodenum, and five had ulcers the site of which was not stated. These fifteen patients are omitted from subsequent detailed consideration.

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The results of analysis of the remaining 839 patients are presented below. Attack rates have been calculated from figures supplied by the Adjutant General's branch for the strength of the Army in 1955 and are average figures for the year for male personnel. These figures cannot be published and only approximate figures may be given in the text. The ages given are ages at the time of diagnosis, not at onset of symptoms.

Results

There were 864 ulcers in 854 men, and the patients may be classified as follows:

Duodenal ulcers	742
Gastric ulcers	97
Peptic ulcers—site not specified	5
Ulcers at both sites	10

The incidence of duodenal ulcer was 1·8 per thousand men, and that of gastric ulcer 0·2 per thousand. The ratio of duodenal to gastric ulcers, excluding ulcers at both sites, is 7·65:1. The figures of the various age groups are given in Table I and the attack rate per thousand men by ages in Table II.

Table I

AGE INCIDENCE AND RATIO OF DUODENAL : GASTRIC ULCERS

Age Group (yrs)	Duodenal Ulcer		Gastric Ulcer		Ratio Duodenal:Gastric Ulcer
	Number of Cases	Percentage Distribution	Number of Cases	Percentage Distribution	
17–19	160	21·6	21	21·6	7·6:1
20–24	247	33·3	29·	29·9	8·5:1
25–29	104	14·0	13	13·4	8·0:1
30–34	67	9·0	8	8·2	8·4:1
35–39	71	9·6	11	11·3	6·5:1
40–44	62	8·4	5	5·2	12·4:1
45+	31	4·2	10	10·3	3·1:1
Total	742	100	97	100	7·65:1

Table II

ATTACK RATE FOR DUODENAL ULCER AND GASTRIC ULCER PER THOUSAND MALE ARMY PERSONNEL, BY AGE GROUP

Age Group (yrs)	Duodenal Ulcer		Gastric Ulcer		Incidence of All Types of Ulcer (per 1,000 men)
	No. of Cases	Incidence (per 1,000 men)	No. of Cases	Incidence (per 1,000 men)	
17–19	160	1·0	21	0·1	1·1
20–24	247	1·5	29	0·2	1·7
25–29	104	3·7	13	0·5	4·1
30–34	67	3·8	8	0·5	4·3
35–39	71	4·1	11	0·6	4·7
40–44	62	4·5	5	0·4	4·9
45+	31	3·7	10	1·2	4·9
Total	742	1·8	97	0·2	2·1

Perforated ulcers are shown separately in Table III.

Table III

PERCENTAGE OF ULCERS WHICH PRESENTED WITH PERFORATION, BY AGE GROUP

Age Group (yrs)	Duodenal Ulcer		Gastric Ulcer	
	Number Perforated	Percentage Perforated	Number Perforated	Percentage Perforated
17–19	27	16·9	4	19
20–24	22	8·9	6	21
25–29	14	13·5	2	15
30–34	9	13·4	0	—
35–39	5	7·0	0	—
40–44	4	6·5	1	20
45+	4	13·0	1	10
Total	85	11·5	14	14·4

Nature of the Population Surveyed

In 1955 the British Armed Forces received by conscription for 2 years almost all young men not medically unfit. Most entered the Army at the age of 18, but some were allowed deferment for a period of years. Thus National Servicemen form the vast majority of men aged 17–20 in the Army, many of those aged 20–24, and some of those aged 25–29. All others are on regular engagements.

Recruits are drawn from all parts of the United Kingdom, and include all social classes and most occupations, except that certain groups, notably coal miners, merchant seamen, and farm workers, are exempted from military service altogether. The National Servicemen are to that extent representative of the British population. There are, however, certain minimum medical standards for entry, and patients with known peptic ulcers are not accepted. Regular soldiers are not representative of the population of Britain, as they have volunteered for a particular type of life, have been especially selected for fitness, would have been rejected if they had had an ulcer, and might well have been discharged if they had developed one.

It is widely known in the Army that stomach trouble may lead to a period in hospital and even to invaliding out of the Army. These events probably tend to make long-service regulars delay reporting their dyspepsia and also to have the opposite effect on National Servicemen. Army routine with fairly long intervals between meals tends to exacerbate dyspeptic symptoms. Almost all patients with major dyspepsia are referred for barium meal examination at a hospital, and, unlike civilian life, there is no difficulty in admitting such patients to hospital for investigation and treatment.

We have studied other population surveys and their selectivity. Knutsen and Selvaag (1947)

analysed the extra ration certificates for radiologically proven ulcers in 1942 in Drammen, a representative town of 25,000 inhabitants in occupied Norway. The incentive of extra rations guaranteed the inclusion of almost all dyspeptics. Their paper does not, however, mention the whereabouts at that time of males of military age. Doll and others (1951) do not consider the community they studied to be representative of the general population with reference to age, sex, geographical location, and occupation.

Incidence of Duodenal Ulcer

Table II shows the incidence of newly-diagnosed duodenal ulcers by age groups. It is considered that the 19 year-olds are the group in this series likely to correspond most closely to the same age group of the whole male population of the United Kingdom, as selective factors operate least strongly at this age In about 100,000 soldiers aged 19, there were 102 duodenal ulcers, that is, 1·0 per thousand. Figures for comparison in other series are scanty. Knutsen and Selvaag found three duodenal ulcers in 903 males aged 15–19, and Doll and others (1951) found one in 199 males aged 14–19 years.

The attack rate for duodenal ulcer rises to a maximum of 4·5 per thousand in the 40–44 age group. This peak age group is the same as that found by Doll and others (4·1 per cent. at 40–44) and Knutsen and Selvaag (4·0 per cent at 40–49), but the overall incidence in these surveys is nine times that in the present series. The non-recruitment to the Army of known ulcer sufferers, the invaliding of many ulcer patients, and the restriction of this series to ulcers diagnosed for the first time in 1955 may account for these differences.

In 1942–5, 63,957 duodenal ulcers were diagnosed in the United States Army, giving an annual rate of 2·51 per thousand men on the strength. The figures were not analysed by ages and are based on a preliminary sample only, the bases for diagnosis not being stated. The 1937–41 figures, which are final, give a similar figure of 2·47 per thousand (Hamilton, Sullivan, and Palmer, 1952).

Incidence of Gastric Ulcer

There were seventeen gastric ulcers in about 100,000 19-year-old soldiers, an attack rate of 0·16 per thousand. There were no patients with gastric ulcers at this age in the series of Knutsen and Selvaag or Doll and others. The attack rate for gastric ulcer in the present series appears to rise with age.

Duodenal/Gastric Ulcer Ratio

Table I shows that the ratio of duodenal to gastric ulcer in all age groups was 7·65:1. This may be compared with 10:1 in the United States Army in 1942–5, and 5:1 in 1937–41 (Hamilton and others, 1952); their figures are also based on in-patient hospital series. Tidy (1943) found a ratio of 4·6:1 in an analysis of 800 military patients discharged from hospital in 1942.

The ratio under 45 years of age in the present series is 8·2:1. This may be compared with 2·3:1 in the men under 45 years of age reported by Doll and others, and of 2·3:1 of men under 50 years of age in the Drammen series. Two British civilian series of hospital in-patients and out-patients in London (Jones and Pollak, 1945) and Glasgow (Jamieson, Smith, and Scott, 1949) give ratios for men under 45 of 5·5:1 and 13·2:1 respectively. It is generally agreed that the ratio is higher in Scotland than in England, and the figure of 8·2:1 in the Army, a mixed British population, is intermediate. The ratio varies slightly with age, but no conclusions have been drawn because of the small number of gastric ulcers.

Perforated Ulcers

Table III shows that 11·5 per cent. of duodenal ulcers and 14·4 per cent. of gastric ulcers presented with perforation. The comparable figures of Jones and Pollak (1943) are 11·7 per cent. of duodenal ulcers and 5·3 per cent. of gastric ulcers. These figures for duodenal ulcers are very similar to the 10·6 per cent. of Brooke (1950), who studied a one-fifth sample of all service cases admitted to E.M.S. hospitals 1940–7. She found in addition that 24·9 per cent. of 1,783 gastric ulcers presented with perforation, but the series here includes peptic ulcers (site not stated) and the validity of this large proportion may be questioned on that ground. It is also known that perforated ulcers thought at operation to be gastric may subsequently prove to be duodenal, a criticism that may also be applied to the present series.

Summary

All in-patient case summaries of peptic, gastric, and duodenal ulcer patients in the British Army in 1955 were sought, and 99 per cent. were found, examined, and, assessed. In 1955, 742 duodenal and 97 gastric ulcers were diagnosed for the first time in approximately 400,000 male soldiers. The overall incidences of duodenal and gastric ulcers were 1·8 and 0·2 per thousand men respectively. The data

were analysed by age, and attack rates were estimated in the various age groups for proven gastric and duodenal ulceration, together with the proportions presenting with perforation.

We are greatly indebted to Mr. D. T. Beeston of the Army Medical Statistics Branch, the War Office, for making available to us the medical records of patients with ulcers in the Army, and for his criticism and advice. We wish to thank the Director-General, Army Medical Services, for permission to publish.

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MORBIDITY IN THE INSURED POPULATION OF NORTHERN IRELAND

BY

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A committee of inquiry known as the Tanner Committee (1955), set up by the Government of Northern Ireland to survey the Health Services, stated in their comment on the relatively high cost to the National Insurance Fund of sickness in the insured population: "It may be that there is a greater incidence of illness in Northern Ireland than in other parts of the United Kingdom".

This speculation has been made on many occasions as it is a fact that since the inception of sickness benefit schemes an appreciably higher relative expenditure has been experienced in Northern Ireland than in Great Britain.

In the absence of any complete morbidity data or reasonably representative samples of such data in the United Kingdom, it is impossible to prove or disprove any generalizations on community ill-health. It is felt, however, that a general survey of some statistical data available to us, with, where possible, comparisons between our figures and those published in other parts of the United Kingdom, may be of interest. The amount and duration of sickness in the insured population will be considered together with an estimate of the size of the chronic and long-term sickness problem.

Definitions.—Those recommended in the Report of the Statistics Sub-Committee of the Registrar General's Advisory Committee (General Register Office, 1954) have been followed with the following additions:

(*a*) Long-term Sickness—spells of incapacity of more than 1 years' duration.

(*b*) Chronic Sickness—spells of incapacity of more than 2 year's duration.

(*c*) Other Women—single, widowed, and divorced women.

UNEMPLOYMENT.—The Province suffered severely from the depression in the early 1930s, and for a few years one in four of the insured population was unemployed. The position has greatly improved since 1945 with the introduction of new industries and the high level of employment in Great Britain but, despite this, unemployment is heavy in comparison with the rest of the United Kingdom. The average percentage unemployed in 1956 was 6·4 per cent. of insured employees compared with 1·2 per cent. in Great Britain.

Unemployment in Northern Ireland is subject to violent seasonal fluctuations: in 1956 for instance, the October figure of 25,309 was some 13,000 lower than the January figure and this is typical of the trend each year.

There is also an appreciable regional variation in the level of unemployment, the unemployment rate in the Belfast conurbation being much lower than in such areas as Newry, Enniskillen, and the surrounding rural districts.

A great deal of publicity is given to the large number of persons registered as unemployed in Northern Ireland, but little reference is made to the number absent from work because of sickness The number on the sickness register has never fallen below 30,000 since the inception of the National Insurance Schemes in 1948.

NUMBERS EXPOSED TO RISK.—In general all employees and self-employed persons between school-leaving age and the date of retirement are insured against sickness, the main exceptions being those married women who elect not to pay contributions and those self-employed persons who claim exemption on the grounds that their income calculated in accordance with the requirements of the Act is less than £156 a year.

In addition, special conditions in the regulations governing sick pay of the civil service and police have the result that the Ministry of Labour and National Insurance has no direct information about morbidity in these employments and they, together with members of H.M. Forces, have been excluded from all the data that follow.

Under the National Insurance Act (Northern Ireland) 1946, persons with the appropriate insurance qualifications are entitled to claim sickness

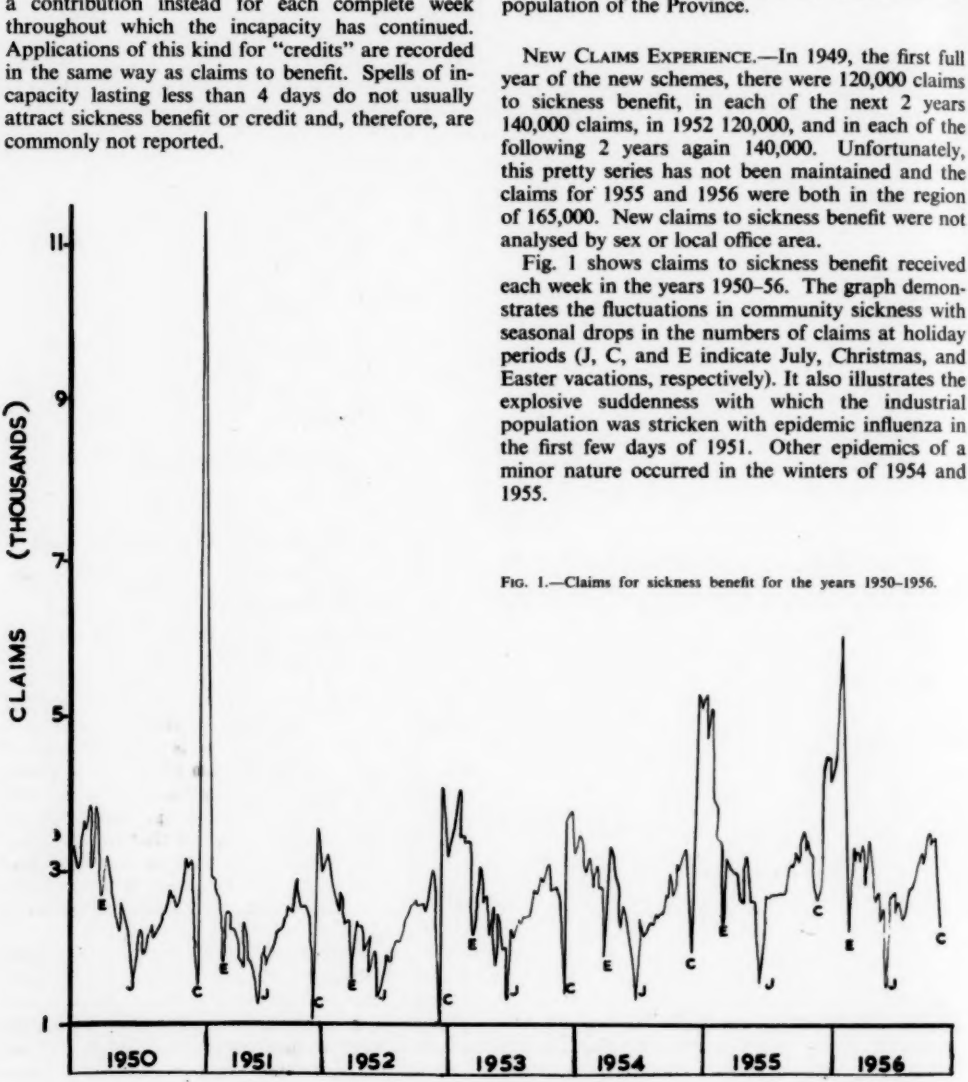
benefit for periods during which they are "incapable of work by reason of some specific disease or bodily or mental disablement". Persons who are not entitled to benefit because they have exhausted their rights or have insufficient contributions to their credit to qualify, may present evidence of incapacity for work to secure release from the obligation to pay weekly contributions, and to be credited with a contribution instead for each complete week throughout which the incapacity has continued. Applications of this kind for "credits" are recorded in the same way as claims to benefit. Spells of incapacity lasting less than 4 days do not usually attract sickness benefit or credit and, therefore, are commonly not reported.

When we exclude members of the Forces, civil servants, and police, there are approximately 505,000 persons covered for sickness benefit in Northern Ireland. The approximate sex distribution is 340,000 men and 165,000 women (35,000 married and 130,000 other women). These numbers represent about 80 per cent. of the males and 40 per cent. of the females in the corresponding age groups in the population of the Province.

NEW CLAIMS EXPERIENCE.—In 1949, the first full year of the new schemes, there were 120,000 claims to sickness benefit, in each of the next 2 years 140,000 claims, in 1952 120,000, and in each of the following 2 years again 140,000. Unfortunately, this pretty series has not been maintained and the claims for 1955 and 1956 were both in the region of 165,000. New claims to sickness benefit were not analysed by sex or local office area.

Fig. 1 shows claims to sickness benefit received each week in the years 1950–56. The graph demonstrates the fluctuations in community sickness with seasonal drops in the numbers of claims at holiday periods (J, C, and E indicate July, Christmas, and Easter vacations, respectively). It also illustrates the explosive suddenness with which the industrial population was stricken with epidemic influenza in the first few days of 1951. Other epidemics of a minor nature occurred in the winters of 1954 and 1955.

FIG. 1.—Claims for sickness benefit for the years 1950–1956.



REGIONAL VARIATION.—The regional aspect of sickness can be examined in more detail from a count of all current cases in receipt of sickness benefit or credit. As a result of such a count at the end of August, 1955, when there were 36,000 persons incapacitated through sickness, it was estimated that the point prevalence rate was 7·1 per cent. of the population exposed to risk—6·2 per cent. for men and 9·0 per cent. for women (it was not possible to separate the married women from the others). It is very difficult to calculate the numbers exposed to risk in each local office area, but so far as we can estimate the point prevalence rate was 10 per cent. or higher in the following areas: Newry, Dungannon, Enniskillen, Omagh, Magherafelt, Cookstown, Armagh, and Ballymoney. These are mostly agricultural areas where seasonal unemployment is a major problem.

LIMITATIONS OF DATA.—The available statistics on diagnosis are of a secondary nature in that they were compiled initially for the Government Actuary who makes annual and quinquennial reviews of the National Insurance scheme. They are based on the sickness experience of 20 per cent. of the persons incapacitated and, while this sample may be sufficient for actuarial purposes, when it is broken down into small subdivisions, such as by age, sex, and diagnostic sub-groups necessary for any morbidity study, the figures must be treated with considerable reserve. The figures have been confined to ages 15–64 for men and 15–59 for women except in the comparisons with Scotland.

The nature of the incapacity has been obtained from the diagnosis given by the medical practitioner on the last medical certificate received by the Ministry of Labour and National Insurance; where this diagnosis is not explicit (for example, "convalescence" or "debility") the last preceding diagnosis that it sufficiently specific has been used. The diagnosis has been coded according to the International Statistical Classification of Disease (1948) and the diagnoses have been grouped into the eighteen cause groups originally used in the quarterly reports on the sickness surveys carried out by the Social Survey and published in the quarterly return of the Registrar General for England and Wales.

INCEPTION RATES.—The number of spells of sickness which started during the year per 1,000 persons exposed to risk are shown in Table I.

Fig. 2 shows the inception rates for men, married women, and other women by age groups averaged over the 6 years 1950–55 inclusive. As the number of married women exposed to risk in each age group is small, their rates should be treated with caution.

TABLE I

NUMBER OF SPELLS OF SICKNESS STARTING DURING EACH YEAR, PER 1,000 PERSONS EXPOSED TO RISK, BY SEX

Year	Men	Women	
		Married	Other
1950	219	558	263
1951	248	560	290
1952	209	447	225
1953	235	550	252
1954	229	543	250
1955	267	597	312

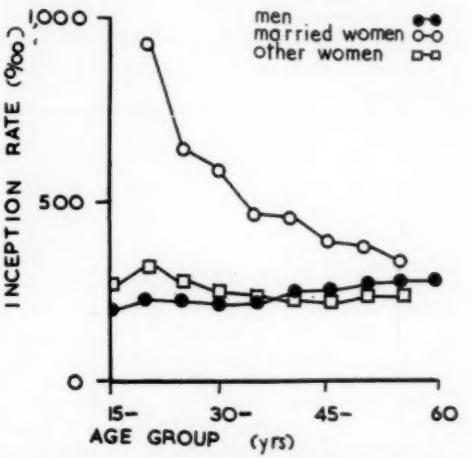


FIG. 2.—Inception rates (spells of sickness) per 1,000 exposed to risk, by age group and sex.

Amongst men there appears to be a slight but definite positive correlation between age and inception rate after age 30. There is a marked negative correlation for married women from the exceptionally high rates at child bearing ages, but, at all ages, the rate for married women is appreciably higher than for other women. The fact that the inception rate for other women falls with age may in some measure be due to only the more robust women remaining in the working population in the older age groups.

Table II (overleaf) gives the inception rates per 1,000 insured for each of the eighteen diagnostic groups for each year 1950–55 in the sex and marital status groups. In the working population there is a higher inception rate for psychoneurosis amongst married women than amongst other women and men.

TABLE II

INCEPTION RATES ACCORDING TO DIAGNOSIS; SHOWING NUMBER OF SPELLS OF SICKNESS PER 1,000 EXPOSED TO RISK, BY SEX, 1950–1955

Population		(a) Men						(b) Married Women						(c) Other Women					
Year		1950	'51	'52	'53	'54	'55	1950	'51	'52	'53	'54	'55	1950	'51	'52	'53	'54	'55
Diagnosis	1. Tuberculosis of Lung	2	2	1	2	2	2	5	3	3	2	2	3	3	3	2	2	2	3
	2. Psychoneurosis and Nervous Disorders	5	4	5	6	6	7	23	23	19	27	24	30	12	13	11	13	13	15
	3. Eye Affections	2	2	2	2	2	2	3	2	2	2	3	3	3	3	2	2	3	3
	4. Ear and Mastoid Affections	2	2	2	2	2	2	2	2	2	2	4	5	3	2	2	3	2	3
	5. Rheumatism	23	25	26	28	27	31	40	35	28	39	44	43	17	15	14	11	15	17
	6. Heart and Arteries	6	6	6	6	7	7	13	12	10	15	14	15	4	4	4	4	4	4
	7. Affections of Veins	4	4	4	4	4	4	10	10	10	10	13	12	4	4	2	3	3	3
	8. Colds and Influenza	39	61	23	37	33	47	40	70	23	46	45	63	41	68	22	40	34	61
	9. Sore Throat	12	9	8	10	9	12	14	12	10	17	15	17	26	20	18	21	20	26
	10. Other Respiratory Disorders	28	32	27	27	27	31	46	63	37	45	48	48	27	32	25	23	24	30
	11. Dental Disorders	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	4	2
	12. Ulcer of Stomach and Duodenum	9	9	9	10	10	10	2	3	3	3	4	4	2	2	2	2	2	2
	13. Other Stomach Disorders	10	12	12	12	14	16	12	16	15	17	18	18	7	8	8	8	7	10
	14. Other Digestive Disorders	7	7	6	5	5	7	9	7	6	11	8	9	12	11	9	9	8	12
	15. Diseases of Skin	16	15	16	15	14	16	16	14	11	18	16	17	17	18	18	18	18	16
	16. Other Defined Illness	26	26	26	26	25	28	*259	235	204	223	196	218	57	57	49	51	45	57
	17. Other Defined Symptoms	12	14	17	20	20	21	47	40	54	61	72	76	18	21	27	29	32	34
	18. Injuries	16	18	18	21	21	23	13	12	9	11	14	16	10	11	9	12	12	14
Total		219	248	209	235	229	267	558	560	447	550	543	597	263	290	225	252	250	312

* Including pregnancy.

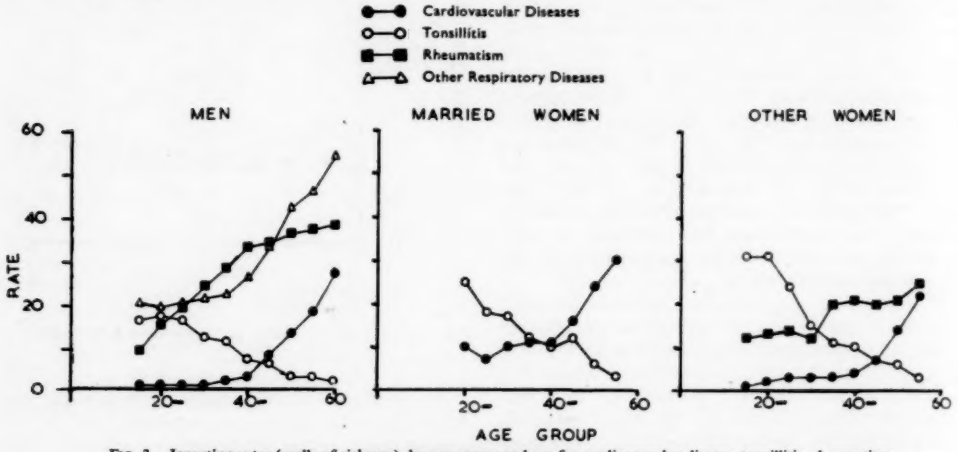


FIG. 3.—Inception rates (spells of sickness), by age group and sex for cardiovascular disease, tonsillitis, rheumatism, and other respiratory diseases.

Rheumatism also is more frequent amongst married women than amongst men and other women. Ulcers of the stomach and duodenum are more common amongst men. The exceptionally high rate for married women in the "other defined illness" group is due to the inclusion of pregnancy in this group.

Fig. 3 shows average inception rates for certain diagnoses for the years 1950–55 according to age: (*a*) Men, (*b*) Married Women, (*c*) Other Women. These graphs show for each class the diagnoses where there is a marked correlation between inception rates and age.

FREQUENCY OF SPELLS OF ILLNESS.—It is estimated that, amongst the insured population covered for sickness, about 21 per cent. of the males, 50 per cent. of the married women, and 22 per cent. of the other women have at least one spell of sickness absence during the year. Of the 71,000 men who had spells of sickness absence starting in 1955, *i.e.* including those sick throughout the year, 57,000 had only one spell, 11,000 two spells, and 3,000 more than two spells, the maximum number of spells being eight. Of the 16,500 married women who had spells starting in 1955, 12,500 had only one spell, 3,000 had two

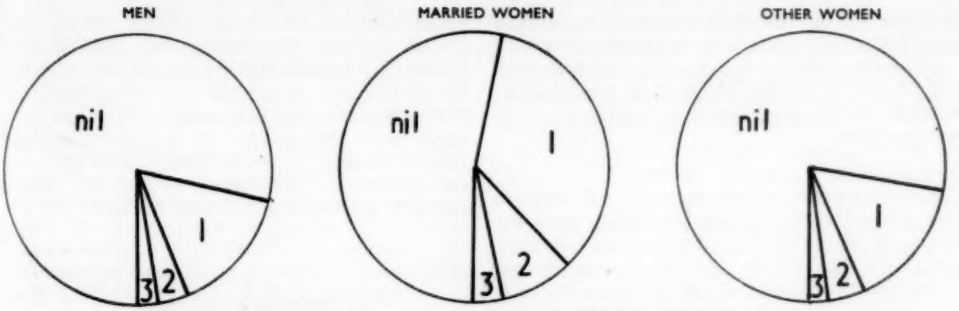


FIG. 4.—Frequency of spells of sickness, by sex. The segment marked 3 includes three spells of sickness and over.

spells, and 1,000 more than two spells, the maximum number of spells being six. Of the 28,000 other women who had spells starting in 1955, 22,000 had only one spell, 5,000 had two spells, and 1,000 had more than two spells, the maximum number of spells being six. These frequencies are illustrated in Fig. 4 (above).

COMPARISONS WITH SCOTLAND.—It is of interest to compare this experience with other areas in the United Kingdom so that evidence can be accumulated for or against the suggestion that Northern Ireland has "abnormally high" sickness rates. It is known from published figures that, whereas the inception rate of spells of sickness is lower in Northern Ireland than in Great Britain, the point prevalence rate is consistently higher. The comparison of the experience in Northern Ireland with that in Great Britain is obviously not a comparison of like with like, and for that reason we investigated the possibility of obtaining details of the sickness experience in one of the regions in Great Britain which would be more akin; we were able to obtain sickness statistics for the year ended 5 June, 1954, based on a 5 per cent. sample for Scotland, but unfortunately the only available details of those exposed to risk in Scotland is that for males in total; no age analysis is available nor even an overall figure for females.

The Scottish figures were analysed according to the Special List of fifty causes with certain extensions, and a similar analysis of the Northern Ireland data resulted in the following comparison:

For the number of new incapacities commencing within a year, it was found that the inception rate for males for Scotland was 334 per 1,000 insured against 252 for Northern Ireland. Table III shows a comparison of the inception rates for some of the more frequent diagnoses. Except for influenza, the Scottish rates were always the higher, but, of course, this might be a function of differencies in the age distribution of the two populations.

TABLE III

NEW INCAPACITIES COMMENCING WITHIN THE YEAR, MALES

Diagnosis	Inception Rates (Spells) per 1,000 exposed to Risk			
	Scotland		Northern Ireland	
Common Cold	10		3	
Acute Tonsillitis	15		8	
Influenza	42		45	
Bronchitis	28		22	
Gastritis	14	153	12	135
Cellulitis	10		6	
Rheumatism	25		24	
Sprains and Strains	9		5	
All Causes	334		252	

With the long-term cases, *i.e.* those incapacitated throughout the year under review, the position is reversed. In Scotland 16·2 males out of every 1,000 exposed to risk had been ill continuously for at least one year while the corresponding figure for Northern Ireland was 25·8. Table IV shows a comparison of these rates for some of the more frequent diagnoses for males. Except for "psychosis", the

TABLE IV

INCAPACITIES LASTING AT LEAST ONE YEAR, MALES

Diagnosis	Number of Spells per 1,000 Insured			
	Scotland		Northern Ireland	
Tuberculosis of Respiratory System	2·6		3·6	
Psychosis	1·6		1·1	
Other Psychoneurotic Disorders	0·6		0·8	
Arteriosclerotic and Degenerative Heart Disease	1·5	9·6	1·8	13·7
Bronchitis	1·3		2·6	
Arthritis	1·0		1·9	
Multiple Sclerosis	0·4		0·6	
Disease of Heart not included Elsewhere	0·6		1·3	
All Causes	16·2		25·8	

Northern Ireland rates were always the higher, but again the age effect cannot be taken into account.

The marked difference in the figures for bronchitis and arthritis is notable; there is no apparent explanation for this difference in the experience of the two countries.

CHRONIC SICKNESS IN NORTHERN IRELAND.—In the case of Northern Ireland we were able to assess the magnitude of the chronic sick problem. Approximately one-third of the claimants on the sickness register have been continuously incapacitated for at least 2 years. In terms of those exposed to risk, 18·8 per 1,000 insured males were chronic cases; the corresponding figure for married women was 58·4 and for other women 23·5. The age distribution of those chronic cases is given in Table V.

TABLE V

AGE ANALYSIS OF CHRONIC SICK AMONGST INSURED POPULATION IN NORTHERN IRELAND AT MAY 31, 1955

Age Groups (yrs)	Men		Women			
			Married		Other	
	Number	Per 1,000 Insured	Number	Per 1,000 Insured	Number	Per 1,000 Insured
Under 20	35	—	—	—	45	—
20–29	325	4·7	245	21·3	430	11·2
30–39	740	10·0	360	40·0	525	35·0
40–49	1,210	16·3	510	56·7	780	60·0
50–59	2,470	40·1	930	143·1	1,275	91·1
60 and Over	1,615	73·4	—	—	5	—
Total ..	6,395	18·8	2,045	58·4	3,060	23·5

Note: Owing to the small numbers of married women in the older age groups these rates should be treated with reserve.

FURTHER COMPARISONS WITH SCOTLAND.—The third group of cases in which a reasonable comparison with Scotland was possible comprised those terminating during the year under review. In this case it was possible to analyse for both males and females according to duration within each diagnostic group. For all causes the median duration for males was 13 days in Scotland and 18 days in Northern Ireland; for females the median was 16 days in Scotland and 19 days in Northern Ireland. When the figures are broken down by diagnosis it cannot too strongly be stated that owing to the size of the sample and the distribution of the durations the estimated median shown may differ considerably from the true median for a particular group, but Table VI includes only diagnoses wherein these effects do not appear to make the comparisons between the countries invalid. Table VI shows that the longer durations in Northern Ireland are not confined to any one group of illness but occur in practically every diagnostic group in the Table. Arthritis merits a much longer period of incapacity in Northern Ireland for both sexes, as does asthma in males and hypertension in females. Coronary disease requires longer for recuperation and even the common cold and tonsillitis require a longer period in both sexes in Northern Ireland.

TABLE VI

COMPARISON OF MEDIAN DURATIONS (IN DAYS) FOR CERTAIN DIAGNOSIS BETWEEN SCOTLAND AND NORTHERN IRELAND

Diagnosis	Median Duration (days)			
	Scotland		Northern Ireland	
	Males	Females	Males	Females
Streptococcal Sore Throat	8	11	11	13
Asthma	14	20	37	22
Anaemias	30	26	30	26
Other Psychoneurotic Disorders	23	24	29	31
Arteriosclerotic and Degenerative Heart Disease	63	—	98	—
Hypertensive Disease ..	48	51	49	73
Varicose Veins	24	27	26	35
Common Cold	8	10	11	12
Acute Pharyngitis	8	9	10	13
Acute Tonsillitis	9	10	11	12
Influenza	10	11	13	13
Bronchitis	16	17	20	20
Chronic Sinusitis	11	13	16	18
Ulcer of Stomach	22	40	38	41
Ulcer of Duodenum ..	24	—	36	—
Gastritis	12	14	23	19
Appendicitis	35	35	33	33
Hernia of Abdominal Cavity	47	—	48	—
Diarrhoea and Enteritis ..	8	11	14	12
Boil and Carbuncle ..	8	9	13	12
Cellulitis	9	10	14	14
Eczema and Dermatitis ..	19	21	30	24
Arthritis	22	38	48	64
Rheumatism	12	17	21	24
Sciatica	20	25	29	30
Cystitis	12	16	21	22
Nervousness, Debility, Headache	16	22	22	23
Sprains and Strains of Joints and Adjacent Muscles ..	11	11	15	12
All Causes	13	16	18	19

DISCUSSION

It is difficult to explain why morbidity experience in Northern Ireland should be so notably different from that in Scotland. The inhabitants of Northern Ireland participate fully in all benefits of the Welfare State, and it cannot be accepted that there is any fundamental, physical, hereditary, environmental, or climatic differences between them and their neighbours. It can be said that, broadly speaking we are comparing like with like in terms of these factors.

From a statistical point of view, if it is a fact that more new sickness claims of a trivial nature are made in Scotland, then it follows that the average duration of sickness will be shorter in that country.

The lower rate for new claims in Northern Ireland suggests that there is less sickness or less desire to "go sick", or more reluctance on the part of doctors to issue initial certificates of incapacity for minor illnesses. None of these are satisfactory explanations.

Longer durations of sickness in Northern Ireland suggest that sickness when it comes is more severe and incapacitating, and that doctors are either more careful about returning their patients to work after illness or, having given a certificate of incapacity, more lax in determining its conclusion. It is probable that a mixture of these possibilities operate and it is difficult to exclude lax certification as a factor.

The extent of semi- and permanent invalidism is a grave aspect of the local problem. It represents considerable human misery and at the same time imposes a serious financial burden on the National Insurance Fund. A study of the specific conditions giving rise to long-term and chronic sickness may well produce interesting results.

SUMMARY

(1) This study was instigated by the knowledge that, on a basis of annual cost to the National Insurance Fund, ill health in a selected population in Northern Ireland is greater than that experienced in the rest of the United Kingdom.

(2) A survey of certain aspects of morbidity in the insured population of Northern Ireland has been made from data compiled under the National Insurance Scheme.

(3) Where valid comparisons are possible between records of sickness in Scotland and Northern Ireland, such comparisons have been made.

(4) New claims to sickness benefit are made less frequently by men in Northern Ireland than in Scotland.

(5) The duration of sickness claims is on average longer in both sexes in Northern Ireland than in Scotland and this difference is relatively more important among men and for certain diagnoses.

(6) There is much more long-term sickness among men in Northern Ireland than in Scotland.

We are most grateful to Dr. P. J. McKinlay, Department of Health for Scotland, who has provided us with statistical material, to Dr. E. A. Cheeseman, Department of Social and Preventive Medicine, Queen's University, Belfast, for his advice and help, and to the Chief Medical Officer, Ministry of Health and Local Government, for permission to publish this paper.

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MORTALITY FROM CORONARY ARTERY DISEASE AND "MYOCARDIAL DEGENERATION" IN THE REPUBLIC OF IRELAND

BY

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Ryle and Russell (1949) published convincing evidence that the number of deaths due to coronary artery disease in England and Wales had increased dramatically between 1921 and 1939, and the Registrar General (1953b) has shown that this increase was maintained through the post-war years. Other workers, particularly Morris and his associates (Morris, 1951; Morris, Heady, and Barley, 1952; Morris, Heady, Raffle, Roberts, and Parks, 1953), have found that, besides causing premature death in certain sections of the community, coronary artery disease is an important cause of morbidity amongst men in their prime. Morris (1955) suggests that among contributory causes of the changing pattern of this disease are the altered way of life ("high development" he calls it) which followed the Industrial Revolution in "Western" countries.

The 26 counties which make up the Republic of Ireland* have, to a great extent, been spared the evil consequences of the Industrial Revolution. Dublin, the capital, has over 500,000 inhabitants, but this population is more concerned with commerce and the mechanics of government than with industry. Nowhere else in the state is a town or city to be found which has over 80,000 inhabitants, nor is there any industrial centre in the sense that Bradford, Bremen, or Pittsburgh are industrial. Moreover the *modus vivendi* of many rural communities in the Western counties (Donegal, Sligo, Mayo, Galway, Clare, and Kerry) has been little affected by the advent of such 20th century innovations as electricity and the internal combustion engine. Thus, it seemed that an analysis of deaths in the Republic, certified as due to coronary artery disease or "myocardial degeneration" over the past 30 years might be of some value.

Unfortunately, it has proved impossible to include statistics from Northern Ireland, because the Registrar General there has always combined deaths from coronary artery disease and myocardial degeneration under a single heading, and we have considered it desirable to treat these two groups separately.

Data

The data are drawn from annual reports of the registration of births, marriages, and deaths in the Republic of Ireland from 1926–1957, prepared on behalf of the Registrar General. In these reports, certified deaths, analysed by sex and quinquennial age groups, are classified according to the Intermediate International List. Since 1926 this list has been revised three times, but is has proved possible to distinguish between myocardial degeneration and coronary artery disease in such a way as to obtain a reasonably coherent series for each over the whole period. Details of the International List numbers which have been adopted for this study are given in Table I (opposite).

In order to make certain comparisons between deaths in the Republic of Ireland and other countries, data have been taken from the Reports of the Registrar General for England and Wales (1928–1957) and for Scotland (1928–1957), and of the World Health Organisation (1956).

Results

SECULAR TREND.—The comparative mortality indices for males and females in respect of coronary artery disease and myocardial disease from 1926–1956 are shown in Fig. 1 (overleaf). Throughout the period,

*The constitution and official name of the state have changed more than once since it achieved its independence in 1922. Throughout the present paper we shall use this name regardless of the period to which we are referring.

TABLE I

DESCRIPTION OF DISEASES CLASSIFIED AS CORONARY ARTERY DISEASE AND MYOCARDIAL DISEASE

Date	Coronary Group		Myocardial Group	
	International List No.	Definition	International List No.	Definition
1926–30 (Third Revision)	89	Angina pectoris	90(*b*) 90(*c*) 91(*b*)	Fatty heart Other and unstated forms of heart disease Arteriosclerosis
1931–39 (Fourth Revision)	94	Diseases of coronary arteries and angina pectoris	93(*a*) 93(*b*) 93(*c*) 93(*d*)	Acute myocarditis Fatty heart Chronic myocarditis, myocardial degeneration Other and unspecified diseases of the myocardium
1940–49 (Fifth Revision)	94	Diseases of coronary arteries and angina pectoris	93	Diseases of the myocardium
1950–56 (Sixth Revision)	420.0 420.1 420.2	Arteriosclerotic heart disease Heart disease specified as involving coronary arteries Angina pectoris without mention of coronary arteries	422.0 422.1 422.2	Fatty degeneration of the heart Myocardial degeneration with arteriosclerosis Other forms of myocardial degeneration

the mortality due to coronary artery disease has increased for both sexes*; so much so that for every male or female death from this disease in 1926 there were over thirty deaths in 1956. It will be noted, however, that for both sexes the increase was temporarily checked during the period 1940–1943, a time when death rates from the same cause were falling in England and Wales (Registrar General, 1953b).

The change in the death rates due to myocardial degeneration is not nearly so striking; the fall in both sexes between 1930 and 1931 was presumably due to a change in the International Classification (see Table I). From 1931 there is a slow rise which reaches a plateau during the war years and has been followed during the last decade by a slow fall.

AGE INCIDENCE.—The age groups of the population which bear the brunt of the increased death rate due to coronary artery disease are indicated in Table II. Here the average annual death rates for each of the three decades studied are given in quinquennial age groups, and the indices for the two subsequent decades are calculated taking the figures

*The slight downward turn in 1956 may be genuine or it may be explained by errors in estimating the age breakdown of the population for that year; for, although a Census of Population was taken in 1951, the considerable volume of emigration renders extrapolation extremely hazardous. The age analysis of the 1956 Census of Population has been halted in the interests of national economy.

TABLE II

AVERAGE ANNUAL DEATH RATES PER 100,000 FOR CORONARY ARTERY DISEASE IN THE REPUBLIC OF IRELAND, BY AGE GROUP, AND SEX

Sex	Age Group (yrs)	Average Annual Death Rate			Indices taking 1926–35 as Unity		Index taking 1936–45 as Unity
		1926–35	1936–45	1946–55	1936–45	1946–55	1946–55
Male	35–	3	10	24	3·7	8·8	2·3
	45–	9	26	74	2·9	8·3	2·9
	50–	14	54	137	4·0	10·1	2·5
	55–	22	79	222	3·5	9·9	2·8
	60–	34	119	306	3·5	9·0	2·6
	65–	42	138	435	3·3	10·2	3·1
	70–	47	146	536	3·1	11·3	3·7
	75–	43	153	627	3·6	14·8	4·1
	80 and Over	35	102	565	2·9	16·2	5·5
Female	35–	1	5	9	3·7	7·2	2·0
	45–	5	10	25	2·2	5·4	2·4
	50–	7	20	52	3·0	7·8	2·6
	55–	11	32	103	2·9	9·2	3·2
	60–	18	54	174	3·0	9·7	3·2
	65–	17	76	242	4·5	14·4	3·2
	70–	23	79	329	3·5	14·5	4·1
	75–	19	84	419	4·3	21·6	5·0
	80 and Over	17	94	440	5·6	26·2	4·7

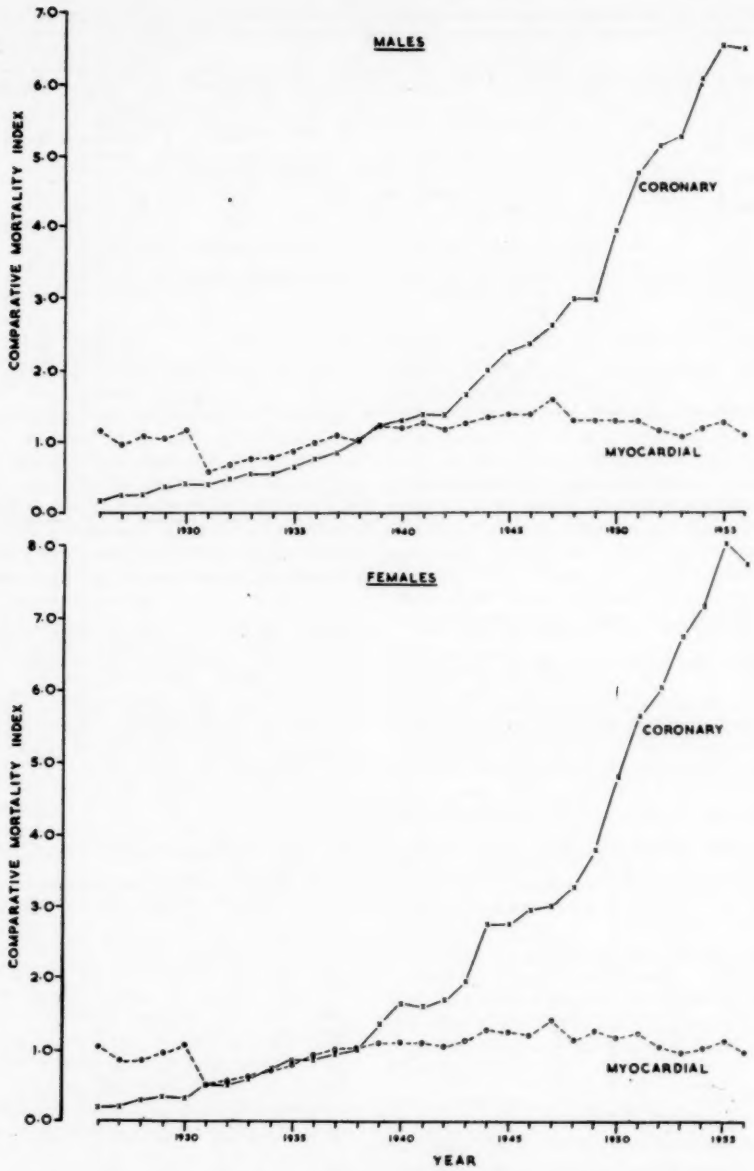

FIG. 1.—Comparative mortality indices for coronary artery disease and myocardial degeneration in the Republic of Ireland from 1926 to 1956, by sex.

for the period 1926–1935 as unity. The sharpest increase in male deaths during the decade 1936–1945 was experienced in middle age; during the following decade, however, the increases in all age groups between 35 and 64 were very similar the most pronounced rise being in men aged 65 years and over. This is also true when death rates for the decade 1936–1945 are taken as unity and the index calculated for 1946–1955.

The pattern of female deaths is a little different, for, during the decade 1936–1945 as compared with 1926–1935, sharp rises occur among those aged 65 and over, and during the decade 1946–1955 the gradient rises almost without interruption from 7·2 in the youngest group to 26·2 in the oldest. If the period 1946–1955 is compared with the preceding decade a similar pattern is manifest; in women who are probably still fertile, mortality is only doubled, whereas in those aged 70 and over the increase is between four- and five-fold.

SEX DIFFERENCES.—Fig. 2, in which the comparative mortality indices are plotted on a ratio scale, shows that the rate of increase in women seems to be consistent with that in men throughout the 30 years under study. A further analysis of sex differences, taking age into account, is shown in Table III, where the ratios of male to female death rates for each of the three decades are compared. During the decade 1926–1935, the ratio is in the order of two male deaths for every female death for the entire age range. In the succeeding decades, however, the

TABLE III

SEX RATIO (M/F) FOR CORONARY ARTERY DISEASE MORTALITY IN IRELAND, BY AGE GROUP

Age Group (yrs)	Decade		
	1926–1935	1936–1945	1946–1955
35–	2·1	2·1	2·5
45–	2·0	2·5	3·0
50–	2·0	2·7	2·6
55–	2·0	2·5	2·2
60–	1·9	2·2	1·8
65–	2·5	1·8	1·8
70–	2·1	1·8	1·6
75–	2·2	1·8	1·5
80 and Over	2·1	1·1	1·3

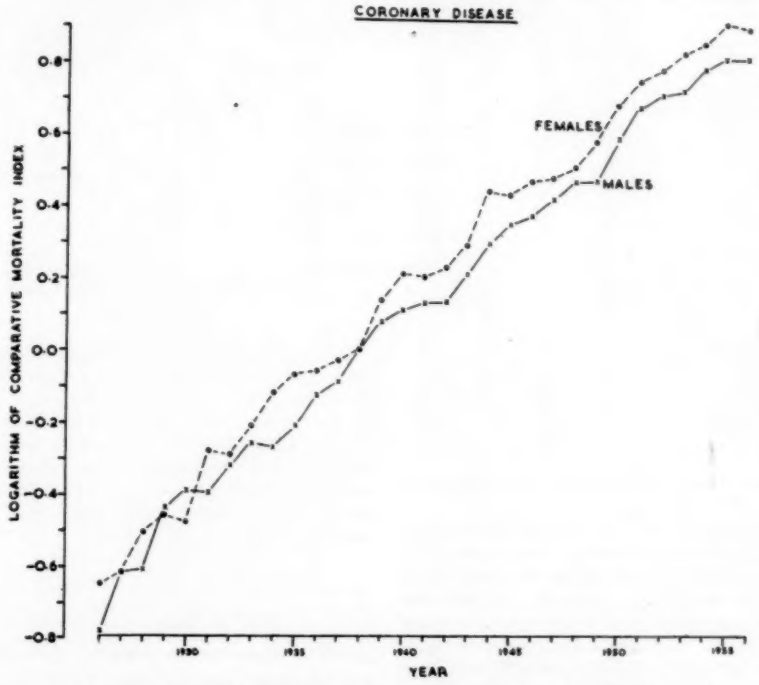

FIG. 2.—Comparative mortality indices for coronary artery disease plotted against a logarithmic scale.

ratio reaches the level of three to one in the younger age groups and decreases to about three to two for persons aged over 70. The "peak" ratio also moves forward steadily, so that it occurs earlier in life as the overall death rate rises. It will be shown below that similar secular patterns have occurred in England and Wales and in Scotland.

GEOGRAPHICAL DISTRIBUTION IN THE REPUBLIC OF IRELAND.—The death rates for the period 1951 to 1955, standardized against the population in 1951, for the counties and county boroughs in the Republic are shown in Table IV (see also Fig. 3), and in Figs 4 and 5 (opposite).

TABLE IV

AVERAGE ANNUAL MORTALITY RATES PER 100,000 (AT AGE 35+) FOR COUNTIES AND BOROUGHS FOR 1951–1955 BY SEX

Disease		Coronary		Myocardial	
Sex		Male	Female	Male	Female
Counties	1. Carlow	254	191	630	546
	2. Cavan	220	131	379	375
	3. Clare	158	76	436	398
	4. Cork	262	135	456	494
	5. Donegal	249	121	323	322
	6. Dublin	372	168	427	437
	7. Galway	243	152	316	389
	8. Kerry	218	106	331	307
	9. Kildare	274	148	532	423
	10. Kilkenny	324	126	537	467
	11. Laoghis	254	123	535	480
	12. Leitrim	137	43	488	485
	13. Limerick	193	83	437	419
	14. Longford	190	110	630	600
	15. Louth	274	121	517	513
	16. Mayo	180	83	259	223
	17. Meath	344	174	547	548
	18. Monaghan	303	128	409	430
	19. Offaly	271	89	468	444
	20. Roscommon	156	94	549	461
	21. Sligo	184	76	375	365
	22. Tipperary, N.R.	294	189	401	331
	23. Tipperary, S.R.	290	141	548	511
	24. Waterford	277	159	449	470
	25. Westmeath	276	131	397	384
	26. Wexford	272	147	504	517
	27. Wicklow	362	164	522	455
Boroughs	28. Cork C.B.	449	212	615	605
	29. Dublin C.B.	453	213	427	454
	30. Dun Laoghaire B.	621	246	422	426
	31. Limerick C.B.	299	124	517	536
	32. Waterford C.B.	270	124	742	742
Republic of Ireland		277	142	433	429

In general terms it will be seen that deaths from both types of heart disease are commoner east of the Shannon than west of the Shannon in males and in females. When urban and rural communities are compared, it is apparent that deaths from coronary artery disease are very much commoner in both sexes in the boroughs of Dublin, Cork, and Dun Laoghaire than in any of the counties, and that very much the highest figure is found in Dun Laoghaire. Although the towns of Limerick and Waterford have a death rate from coronary artery disease in males which is similar to that of the counties on the eastern seaboard, the death rate for females in these two towns is lower than in most of the counties and is in the same order as that for women in the midlands and extreme northwest and southwest.

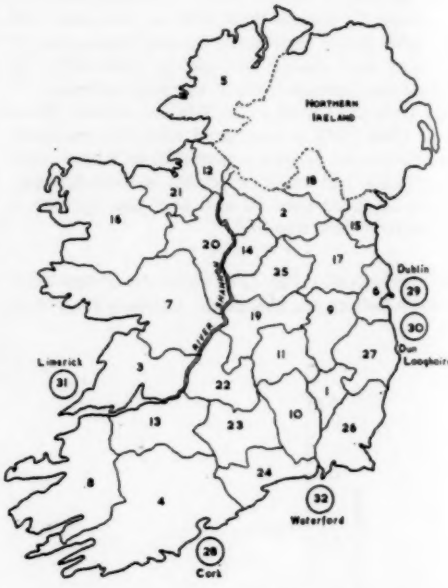

FIG. 3.—Key to counties and boroughs shown in Figs 4 and 5. The numbers refer to the order of listing in Table IV (*q.v.*).

Death was attributed to myocardial degeneration more often in the five boroughs than elsewhere in the country, but it is worth noting that the figures for both sexes are slightly lower for Dublin city and Dun Laoghaire (which is part of the same conurbation as Dublin city) than for the other three major towns. It is also noteworthy that Dublin county has lower death rates for both sexes than the other counties on the eastern seaboard.

FIG. 4.—Average annual death rates, 1951–1955, for coronary artery disease by counties and boroughs (see also Table IV). The scheme used for shading is the same for both sexes in respect of each disease, but different schemes have been used in this and the following Figure.

FIG. 5.—Average annual death rates, 1951–55, for myocardial degeneration by counties and boroughs (see also Table IV).

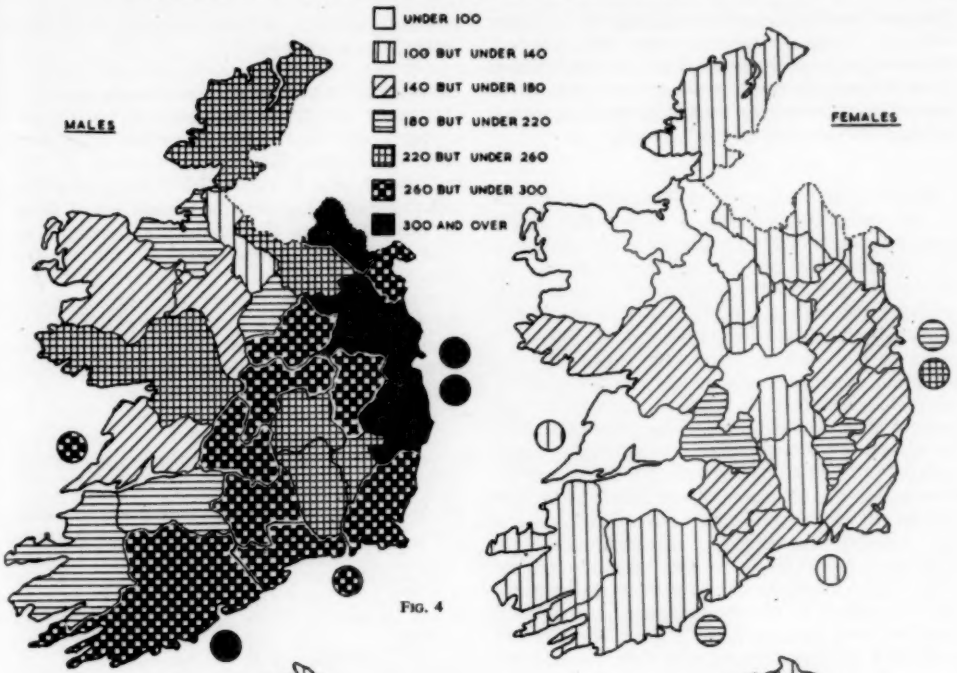
UNDER 100
100 BUT UNDER 140
140 BUT UNDER 180
180 BUT UNDER 220
220 BUT UNDER 260
260 BUT UNDER 300
300 AND OVER
MALES
FEMALES

FIG. 4

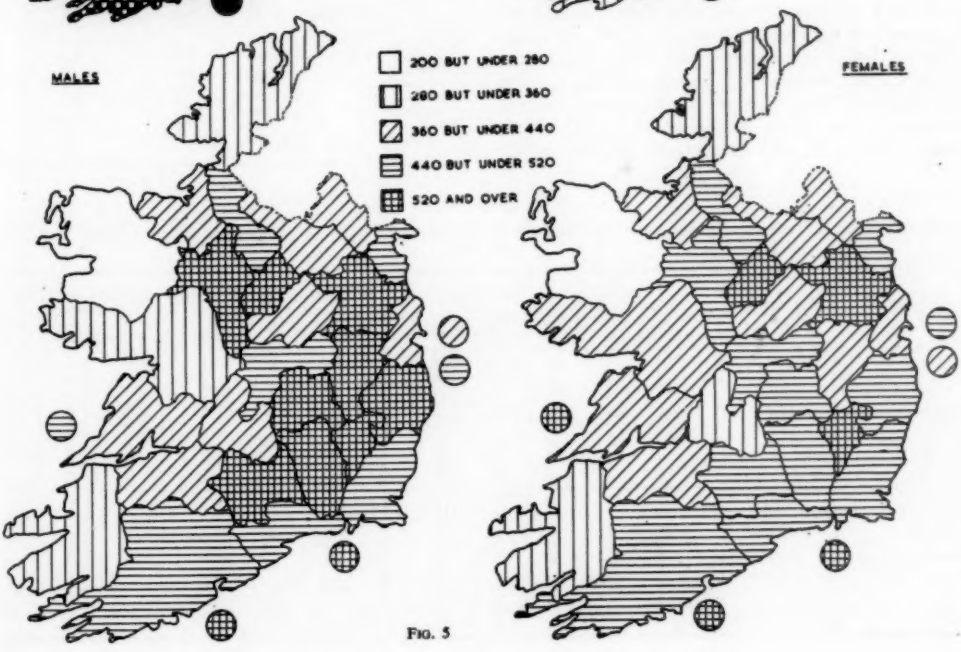
200 BUT UNDER 280
280 BUT UNDER 360
360 BUT UNDER 440
440 BUT UNDER 520
520 AND OVER
MALES
FEMALES

FIG. 5

OCCUPATION AND INCOME.—Although it has been common practice to collect occupational data at a Census of Population, no analyses are published of causes of death by trade or occupation, so that it is impossible at present to determine the occupational incidence of mortality in the Republic.

CORONARY HEART DISEASE IN RELATION TO OTHER CAUSES OF DEATH.—Table V shows the secular trend for deaths due to coronary artery disease as a ratio of all deaths for the various age groups. In men of all ages its importance as a cause of death, as compared with all other causes of death, has increased about eleven-fold during the 30 years under review, and it would seem that, with the exception of men in early middle age in whom the index is highest, this risk is borne equally by all age groups. When a similar comparison is made between the second two decades, however, the highest index is found in the oldest age groups, but the indices for early middle age are again higher than those for late middle age. In women also, early middle age is a time when the importance of coronary disease has increased considerably as a cause of death over the entire 30-year period; but in women, the greatest overall increase of coronary disease as a certified cause of death has occurred in those aged 65 and over, with the peak change in the oldest age groups. Comparison between the decade 1936–1945 and 1946–1955 in women shows much less contrast between the age groups. It is worth pointing out that the indices in Table V reflect the decreasing number of deaths from such causes as puerperal sepsis, lobar pneumonia, and tuberculosis as well as the increasing number of deaths ascribed to coronary artery disease.

COMPARISON OF MORTALITY FROM CORONARY ARTERY DISEASE IN THE REPUBLIC OF IRELAND WITH THAT IN OTHER COUNTRIES.—Table VI shows male and female death rates for various countries in 1954, published by the World Health Organization (1956) and standardized against the population of Ireland in 1951. To these the figures for Ireland during 1954 have been added, and all the countries have been ranked in order of the male death rates. It is interesting that, despite the steady increase in the number of deaths ascribed to this cause, the Republic of Ireland is well down the list; moreover, if the ranking had been made by female deaths, its position would have been even lower.

TABLE VI

DEATH RATES PER 100,000 FOR CORONARY ARTERY DISEASE (AT AGE 40+) FOR VARIOUS COUNTRIES IN 1954, STANDARDIZED TO THE IRISH POPULATION IN 1951

Country	Male	Female	Ratio M/F (to one place of decimals)
1. United States	964	541	1·8
2. Canada	795	435	1·8
3. Australia	711	358	2·0
4. New Zealand ..	689	324	2·1
5. Scotland	638	304	2·1
6. Finland	611	250	2·4
7. England and Wales	559	241	2·3
8. Denmark	527	377	1·4
9. Sweden	408	294	1·4
10. Republic of Ireland	363	184	2·0
11. Norway	356	200	1·8
12. Netherlands ..	327	182	1·8
13. Switzerland ..	295	163	1·8
14. France	144	64	2·2
15. Italy	139	75	1·8
16. Japan	60	34	1·8

TABLE V

AVERAGE ANNUAL DEATHS FROM CORONARY ARTERY DISEASE PER 1,000 DEATHS FROM ALL CAUSES, BY AGE GROUP AND SEX

Sex	Age Group (yrs)	Average Annual Death Rate			Indices taking 1926–35 as Unity		Index taking 1936–45 as Unity
		1926–35	1936–45	1946–55	1936–45	1946–55	1946–55
Male	35–	4	19	65	4·2	14·5	3·4
	45–	10	31	109	3·2	11·2	3·5
	50–	10	41	126	4·2	12·7	3·0
	55–	12	43	136	3·5	11·1	3·2
	60–	11	40	120	3·5	10·5	3·0
	65–	11	33	110	2·9	9·7	3·3
	70–	7	21	84	3·1	12·4	4·0
	75–	4	14	50	3·1	11·4	3·7
	80 and Over	2	5	20	3·3	12·5	3·8
Female	35–	2	9	28	4·4	13·9	3·1
	45–	5	13	38	2·7	7·7	2·9
	50–	5	17	52	3·4	10·7	3·1
	55–	6	20	72	3·2	11·7	3·7
	60–	6	20	74	3·1	11·4	3·6
	65–	5	21	68	4·6	14·6	3·2
	70–	4	13	53	3·6	14·8	4·1
	75–	2	8	33	3·8	15·5	4·1
	80 and Over	1	5	17	5·8	18·3	3·1

It is notable that, although the Irish rating is very much lower than that of Scotland and of England and Wales, the changes that have taken place during the past 30 years in Ireland and in Great Britain are similar.

This is illustrated by the data in Tables III and VII and in Fig. 6.

Table VII (overleaf) shows that in England and Wales there was a peak of 5·4 at age 45–49 in 1926–1935, and a higher peak of 6·9 at age 35–39 in

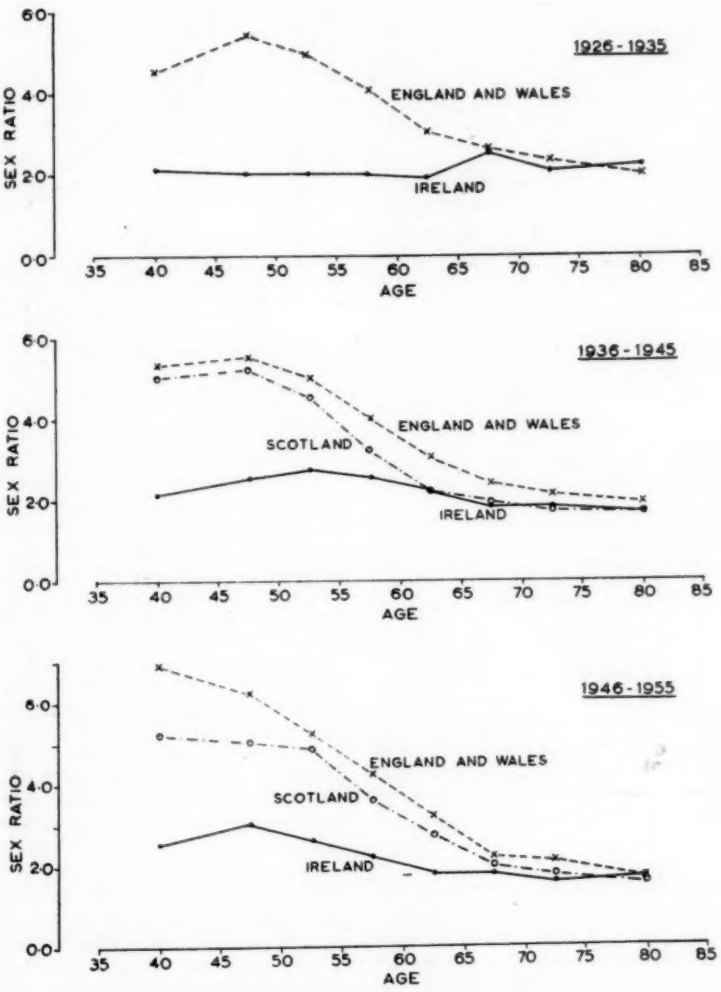

FIG. 6.—Changes in sex ratio of deaths due to coronary artery disease in the British Isles during the past 30 years (see also Table VII). The tendency in each country has been for the peak ratio to occur in an increasingly younger age group. Note that the pattern for Ireland in 1946–1955 is similar to that for Scotland in 1936–1945 and that for England in 1926–35. Note also the similarity between the Irish pattern in 1926–35 and that shown in Fig. 7 for Japan in 1954.

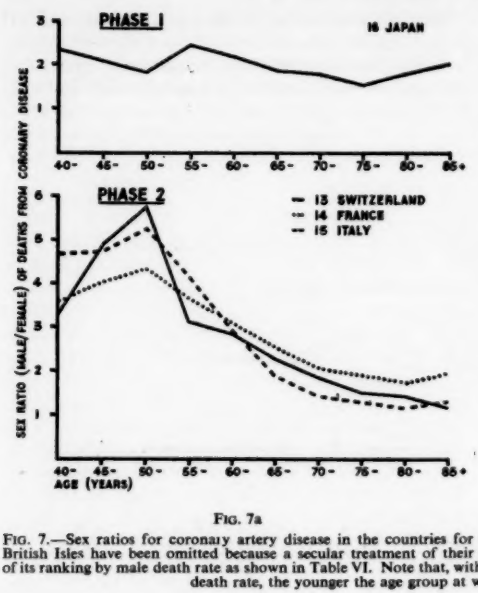

FIG. 7a

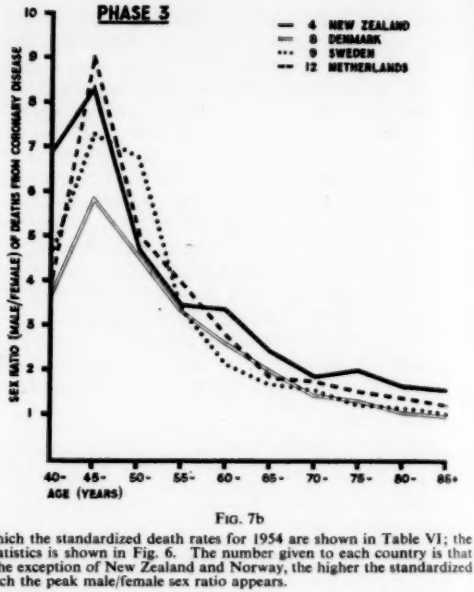

FIG. 7b

FIG. 7.—Sex ratios for coronary artery disease in the countries for which the standardized death rates for 1954 are shown in Table VI; the British Isles have been omitted because a secular treatment of their statistics is shown in Fig. 6. The number given to each country is that of its ranking by male death rate as shown in Table VI. Note that, with the exception of New Zealand and Norway, the higher the standardized death rate, the younger the age group at which the peak male/female sex ratio appears.

TABLE VII

SEX RATIO (M/F) FOR CORONARY ARTERY DISEASE IN ENGLAND AND WALES AND IN SCOTLAND (FOR IRELAND SEE TABLE III)

Age Group (yrs)	England and Wales			Scotland*	
	1926–35	1936–45	1946–55	1936–45	1946–55
35–	4·5	5·3	6·9	5·0	5·2
45–	5·4	5·5	6·2	5·2	5·0
50–	4·9	5·0	5·2	4·5	4·8
55–	4·1	4·0	4·2	3·2	3·6
60–	3·0	3·0	3·2	2·2	2·7
65–	2·6	2·4	2·2	1·9	2·0
70–	2·3	2·1	2·1	1·7	1·8
75+	2·0	1·9	1·7	1·7	1·6

* The population in Scotland aged 35–49 showed a considerable decrease between 1921 and 1931. Presumably this was due to mass emigration during the Depression and followed a normal increase of population in these age groups during the earlier years of the decade. Thus linear interpolation between the two censuses is not a valid method of estimating the age distribution of the population for the interim years. Ratios for the decade 1926–35 have, therefore, been omitted.

1946–1955. The pattern for Scotland is much the same, although the peak ratios are not so high, and in both countries, as in Ireland, the ratios have tended to fall among the oldest sections of the community. Fig. 7 shows the sex ratios for the other countries shown in Table VI; as a rule, it is true to say that the higher the death rate, the younger the age group at which the peak male/female sex ratio occurs. The similarity between the pattern for Japan in 1954 and for the Republic of Ireland in 1926–1935 is worth noting.

Morris (1956) pointed out that the excess in male deaths due to coronary disease in England and Wales for the age group 45–64 was higher in towns than in rural areas. His figures are given in Table VIII (opposite), which shows a similar comparison in Ireland; Connacht (comprising Counties Galway, Leitrim, Mayo, Roscommon and Sligo) was chosen because it is the most rural portion of the country, but County Galway was omitted because a considerable proportion of its population lives in Galway city, which is the largest town in the Republic not enjoying the status of county or metropolitan borough. Thus, our comparison is rather different from that of Morris, because we contrast the country's "most urban" district with its "most rural" district; it is not altogether surprising therefore that, although we also find a greater male excess in the city, our figures are more extreme than his. Yet it is noteworthy that the incidence of deaths in Dublin and district throughout this age range, is lower for both sexes than in rural England and Wales, particularly since Dublin with its ten general teaching hospitals probably maintains as accurate a standard of death certification as any other district of comparable population. It will also be noted that the figures for rural Ireland are the lowest by a considerable margin of the four areas shown in Table VIII.

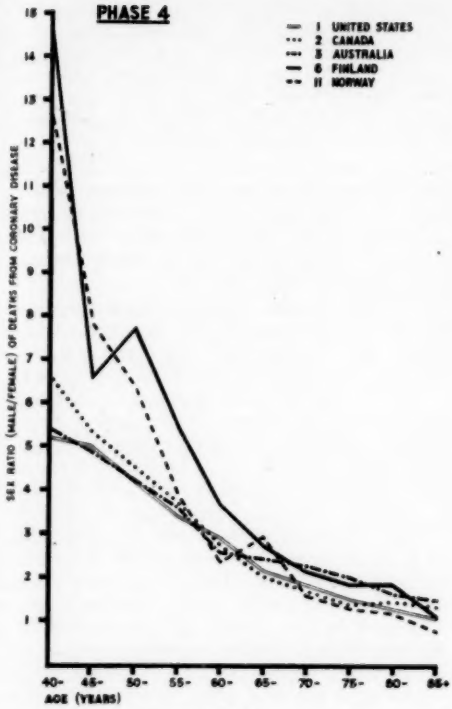

FIG. 7c

The reliability of death certification in this part of the country is discussed below.

DISCUSSION

The comparative mortality indices for coronary artery disease show an increase in the 30 years from 1926 to 1956 which is as remarkable for the way in which it has been sustained through the years as for its degree. The question must arise, however, whether this increase reflects a real change in the prevalence of the disease. The registration of deaths as due to coronary artery disease which were previously registered under other headings, or improved methods of diagnosis, could explain the increase and so deserve consideration.

The first possibility is that deaths formerly reported as being due to myocardial degeneration may now be ascribed to coronary artery disease. This, however, is not a reasonable explanation because the crude death rate for myocardial degeneration per 100,000 of the population aged 35 and over in 1926 was 377 and in 1956 it had *risen* to 388, whereas during the same period the death rates for coronary artery disease had risen from 6 to 238. Thus, there is an overall rise in deaths due to the two causes, but the major part of this has been ascribed to coronary artery disease. Two points require more careful consideration, however; whereas about 2,700 deaths were ascribed to senility in 1956, nearly 8,000 were listed as due to this cause in 1926; secondly, over 10,000 of the deaths which occurred in 1926 were not certified by a medical practitioner as compared with just under 3,000 uncertified deaths in 1956. In fact, these two possible sources of error are inter-related, for about 90 per cent. of the uncertified deaths in persons aged 35 and over actually occurred in persons over the age of 65 years, and during the three decades over 60 per cent. of all uncertified deaths were ascribed to senility. Uncertified deaths and deaths from senility occurred but rarely in urban districts, so that the conclusion may be drawn that as medical attendance at the death of old people in rural areas has become increasingly common, fewer and fewer deaths have been registered as due to senility. Thus, many deaths in people aged over 65 years, which would have been recorded as being due to senility in 1926, were attributed to coronary artery disease in 1956. Whether such deaths in 1926 would have been considered as due to angina pectoris by a medical practioner at that time is of course a different question, and one which, though pertinent, must remain unanswered. Nevertheless, it seems probable that the observed increase in deaths

TABLE VIII

MORTALITY FROM CORONARY DISEASE AT AGES 45–64 PER 100,000 FOR URBAN AND RURAL DISTRICTS IN BRITAIN AND IRELAND OVER SPECIFIED PERIODS, BY SEX

Sex	England and Wales, 1950–52 (Morris, 1956)			Ireland, 1951–55		
	Conurbations	Rural Districts	Per cent. Urban Excess	Dublin and Dun Laoghaire Boroughs	Connacht less Co. Galway	Urban Excess
Male	286	211	35	176	60	193
Female	70	68	3	55	26	111

registered as caused by coronary artery disease in the population aged 65 and over is largely due to more precise certification. It has been suggested to us that the death rates in this age group may now be artificially high because it may be "fashionable" to certify a sudden death in an old person as having been caused by coronary artery disease. Whatever the truth of the allegation about fashion, the conclusion is probably incorrect, because there is some evidence to suggest that the morbidity from coronary artery disease in the elderly is very much higher than the death rate reported so far in any age group in the Republic. It has been found that over 20 per cent. of a small sample of old men in Dublin suffer from angina pectoris and that about the same proportion have asymptomatic coronary heart disease (Acheson and Acheson, 1958). These morbidity figures are very similar to those reported for Sheffield by Droller and Pemberton (1953).

In Table II, however, it was shown that the death rates from coronary artery disease have also increased greatly in persons aged 35 to 64 during the past 30 years; this cannot be attributed to any change in the number of times senility has been recorded as a cause of death, because only about one in ten thousand "senile" deaths have been registered in persons under 65. As was stated above, uncertified deaths are not usual in this age group, so that it may be supposed that among them the accuracy of registration has changed but little. It is therefore interesting that it is in this age group that the biggest changes in sex ratio have occurred (See Table III); moreover, similar trends have been observed in Great Britain and elsewhere (see Table VII and Figs 6 and 7). It is, of course, possible that this trend may be partly explained by improved diagnostic methods, for instance, the more widespread use of the electrocardiograph. Be this as it may, it seems improbable to us that such a consistent alteration in the pattern of the sex ratio can be wholly attributed to any cause other than a genuine change in the epidemiology of the disease itself.

The distribution of deaths due to coronary artery disease in Ireland (Fig. 4) is interesting. The incidence of deaths from this cause is higher, as a rule, in urban than in rural areas, and it is also highest in the east and south of the country, both of which Morris (1955) would describe as the most "highly developed" areas. Moreover, the difference between urban and rural areas is very pronounced in the population aged under 64, in which certification (and probably diagnosis) are more reliable (see Table VIII) as well as in the larger section of the community illustrated in Fig. 4. High development or "westernization" may not, however, be the chief reason for this difference, because anthropological (Hooton and Dupertuis, 1955) and blood group surveys (Hackett, Dawson and Dawson, 1956; Hackett, 1957; Dawson and Hackett, 1958) have shown that in these areas the racial and genetic make-up of the community differs from those found in the areas west of the Shannon. It is possible, therefore, that differences in race as well as in *modus vivendi* contribute to the sharp contrast seen between Connacht and Dublin (Table VIII). A final conclusion cannot be drawn from the present evidence, but two factors indicate that environment is the more important influence.

First, whereas the incidence of deaths due to coronary artery disease in the boroughs of Cork, Dublin, and Dun Laoghaire is very much higher than in the surrounding countryside (See Table IV), no such distinction exists in respect of the distribution of blood groups, which show a gradual gradient across the island, regardless of urban or rural districts (Hackett, 1957; Dawson and Hackett, 1958). Secondly, although the anthropological characteristics and blood group gene frequencies of the Aran islanders resemble those of eastern Ireland and England, rather than those of the neighbouring mainland (Hooton and Dupertuis, 1956; Hackett and Folan, 1958), their methods and standard of living have changed little over hundreds of years. Only one death on the Aran Islands, however, was certified under group 420 between 1951 and 1955 (a male aged 68), and three (two males and one female) under group 422 for the same period;* expected deaths in the population at risk, based upon rates reported for the neighbouring part of the mainland† during the same period, are four in 420 and six in 422 for males, and two in 420 and four in 422 for females. The population at risk is, of course, very small, and these comparisons should be treated with reserve, but the number of deaths reported on the islands is, in fact, much lower than the "expected" figures for both sexes and both notification groups.

Summary

(1) Comparative mortality indices show that, for every death in a man or a woman in the Republic of Ireland certified as due to angina pectoris in 1926, over thirty deaths were certified as being due to angina pectoris or coronary artery disease in 1956.

*A doctor is permanently resident on the islands, so that all illnesses are attended and all deaths certified.

†The comparison has been made with the statistics for the population aged 35 and over in Mayo, a neighbouring county with no large town.

(2) The secular rate of increase in the male and female death rates has been approximately equal and uniform.

(3) Comparative mortality indices for the group of diseases which are now classed as myocardial degeneration show little change for the period 1926–1956 for either sex.

(4) The groups of the population which have borne the brunt of the secular increase in deaths certified as due to coronary artery disease are men in early middle age and old age, and women in old age.

(5) Coronary artery disease is more frequently certified as a cause of death in the boroughs of Cork, Dublin, and Dun Laoghaire than in any rural area; the incidence of deaths attributed to this cause is much higher in rural areas to the east of the Republic than those to the west.

(6) The importance of coronary artery disease as a certified cause of death as compared with all other causes of death has increased greatly in the past 30 years; again, in men the greatest increase is in early middle age and old age, and in women in the older age groups.

(7) The death rate due to coronary artery disease in the Republic of Ireland in 1954 was lower than that in many of the countries whose statistics for that year have been published by the World Health Organization; the average mortality rates for both sexes aged 45–64 in Dublin City and Dun Laoghaire from 1951–1955 were much lower than those in rural *or* urban areas of England and Wales in 1950–1952.

(8) As the incidence of deaths due to coronary artery disease has increased, so the male/female sex ratio in the various age groups has changed, and the greatest changes have been among the younger age groups in whom certification is likely to be less erroneous. It is suggested that the relationship observed in the Republic between overall incidence of deaths due to coronary artery disease and the sex ratio for the various age groups may be a universal phenomenon.

(9) Reasons are given why the increase in deaths reported as due to coronary artery disease in the Republic of Ireland is considered to be a genuine reflection of a change in the prevalence of the disease in the younger section of the community at risk. Improved diagnosis and certification have almost certainly contributed to the increase in registered death rates from this cause in old age.

We are deeply grateful to Dr. M. D. MacCarthy and Mr. J. F. Knaggs of the Central Statistics Office, Dublin, for making available to us a considerable amount of unpublished data.

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AIR POLLUTION AND OTHER LOCAL FACTORS IN RESPIRATORY DISEASE

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The mortal risks of acute episodes such as the London smog of December, 1952, are well recognized, but the insidious effects of lesser but more continuous atmospheric pollution are less clearly understood. Contrasts in bronchitic mortality between Great Britain and Scandinavia, and between town and country in the United Kingdom, strongly suggest that such effects are important. Uncovering the aetiology of a slowly progressive disease like chronic bronchitis involves the study of its evolution from trivial illness to ultimate death and its relation to other respiratory diseases. As a step towards this, we have used the sickness absence experience of British civil servants to supplement the usual mortality data available from the Registrar General's publications.

The British Civil Service offers considerable advantages as a population for epidemiological study. Numbering some 600,000, it has standard conditions of sick pay and superannuation and contains large groups, uniform in pay and job, widely distributed throughout the United Kingdom. The individual sickness absence records, giving the dates of onset and return to work and the certified diagnosis, are available for the whole of an employee's service and are afterwards retained for 10 years. They present a unique opportunity both for longitudinal studies of the natural history of disease and for the more usual cross-sectional study of current morbidity experience. The potential value of these data is evident in Fig. 1 (opposite), which shows the distribution of the average time lost through sickness absence by postmen in different parts of the United Kingdom. This morbidity pattern again suggests the hazards to health of urban life which are so clearly implied by the urban-rural contrast in bronchitis mortality.

The limitations of such material must, however, be emphasized. Any occupational group is selected both by the individual's choice of career and by the employer's policy of recruitment and discharge. In the Civil Service such policy may vary between different occupations and at different periods. The effect of changes in retirement policy on sickness rates in the Post Office from 1891 to 1946 has been shown by Roberts (1948). Moreover, some illnesses may incapacitate, whether temporarily or permanently, those in arduous occupations but not those doing light indoor work. Sickness rates should thus be used with caution as measures of relative occupational risk or trends in morbidity. In ascribing importance to the different sickness rates of postmen and indoor workers, we have therefore looked for changes in this difference with age, locality, or diagnosis. No secular comparison of sick rates has been made. On the other hand, uniform medical standards of recruitment and ill-health retirement are applied by the Civil Service Commission and the Treasury Medical Service over the whole country, and comparisons by locality are largely free from bias due to staff selection as well as from that due to pay and job.

In this study respiratory mortality in the middle-aged population at large is first correlated with measures of air pollution, population density, and domestic overcrowding, in different areas of the United Kingdom. Wastage and sickness rates among civil servants are then related to the same indices in the same areas. There follows a more detailed analysis of morbidity among the same civil servants at different ages and in areas with contrasting degrees of air pollution.

Fog Index of Presumptive Air Pollution

While the acute effects of air pollution can be shown by time relationships, the study of its long-term effects usually depends on local contrasts in

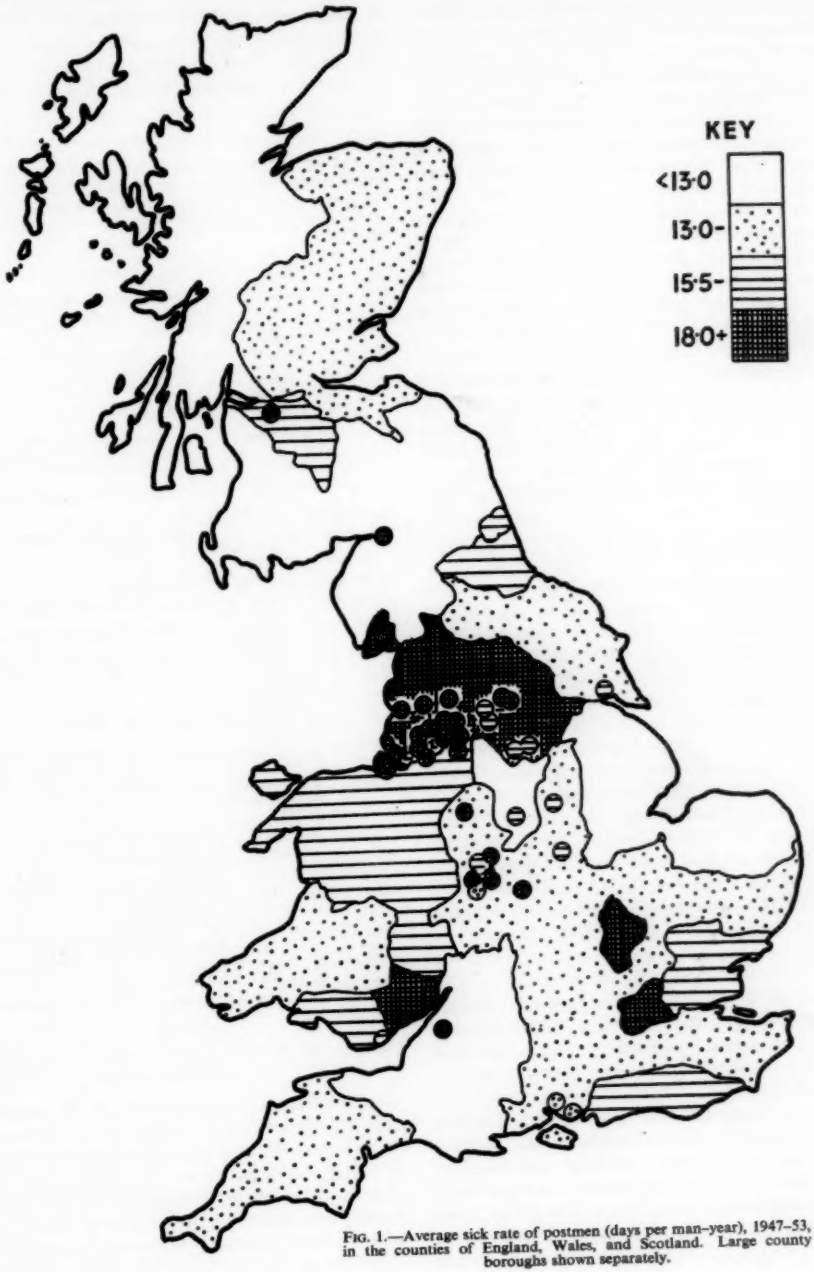

FIG. 1.—Average sick rate of postmen (days per man–year), 1947–53, in the counties of England, Wales, and Scotland. Large county boroughs shown separately.

death and sickness in areas with different atmospheric conditions. Such comparisons have been hampered by the scarcity of stations for measuring air pollutants. Even now, these are largely confined to the more heavily-polluted areas. Pemberton and Goldberg (1954), who correlated bronchitis mortality in the county boroughs of England and Wales with measurements of sulphur dioxide and smoke concentration, could obtain such data for only 37 of them. Daly (1954) calculated an index, based on fuel consumption, for all 83 county boroughs of England and Wales. Because our sickness absence data related to the whole country, we needed a still more comprehensive index which we based on the results of a survey of visibility made in the winters of 1936–7 and 1937–8 (Durst, 1940). In this survey, about 1,000 volunteers stationed in both town and country observed whether, at 9 a.m. each morning, objects could be seen at a distance of 200 yards, 1,100 yards, or 1¼ miles. For each station the index of visibility used was the percentage of occasions on which an object at 1,100 yards was invisible. (The use of alternative ranges makes no material difference to the results.) For an area we took as an index the unweighted average of such frequencies.

Since the concentration of pollutants can increase without visible fog or smoke, visibility is only an indirect measure of atmospheric pollution. Unpolluted mist can occur; but this is mostly in the less populated hilly and coastal districts where it disperses quickly. These local exceptions have little effect on the values of the index for such grouped areas as were used in this study. Durst states that poor visibility is more closely associated with air pollution in winter when these observations were made. The consistency of the index between the two years of the survey and its high correlation with recent measures of sulphur dioxide and with Daly's index of fuel consumption in areas where these were available warrant the assumption that the index is a useful guide to local levels of air pollution.

Selection of Areas

The United Kingdom was divided into the 37 areas listed in Table I, each consisting of one or more administrative districts. Grouping was designed to avoid, as far as possible, sampling fluctuations due to a small Civil Service population or to scarcity of fog measuring stations. At the same time the aim was to combine only fairly homogeneous districts. Neighbouring administrative counties, for example, might form a rural area which excluded any large county borough within it. The more urban areas were generally single county boroughs or larger conurbations. On the other hand, the areas had to be large enough to correspond with the location code used to indicate the place of work in the Civil Service Staff Record. Areas such as Nos. 2, 3, and 16 were thus unavoidably larger than would seem appropriate.

Table I

AREAS OF UNITED KINGDOM RANKED ACCORDING TO INCREASING VALUES OF FOG INDEX, IN FOUR GROUPS OF APPROXIMATELY EQUAL POPULATION

Group	Area
I	1 Northumberland, Cumberland, Westmorland, Yorks (N.R.), Carlisle
	2 All Wales and Monmouthshire (*except* Cardiff)
	3 All Scotland (*except* Glasgow, Lanarkshire, and Renfrewshire)
	4 Southampton
	5 Gloucestershire, Wilts, Somerset, Devon, Cornwall, Gloucester, Exeter, Bath
	6 Bristol
	7 Middlesex
	8 Cheshire, Lancs, Barrow, Blackpool, Southport, Chester
	9 Plymouth
II	10 Bucks, Oxon, Berks, Hants, Dorset, Oxford, Reading, Bournemouth
	11 Surrey, Kent, Sussex, Brighton, Eastbourne, Hastings, Canterbury
	12 Northamptonshire, Northampton
	13 Staffs, Shropshire, Hereford, Worcs, Warwicks, Burton-on-Trent, Worcester
	14 Portsmouth
	15 Preston, Blackburn, Burnley
	16 Norfolk, Ely, Hunts, Cambs, Suffolk, Essex, Herts, Beds, Norwich, Gt Yarmouth, Ipswich, Southend, Cambridge
	17 Middlesbrough, Darlington, Sunderland, West Hartlepool, Durham
	18 Yorks (W.R.), Yorks (E.R.), Doncaster, York
	19 Coventry
	20 Cardiff
III	21 Glasgow, Lanarks, Renfrewshire
	22 Leicester
	23 Leeds
	24 Derbyshire, Notts, Lincs, Rutland, Leics, Lincoln, Grimsby
	25 Newcastle, Tynemouth, Gateshead, South Shields
	26 Bradford
	27 Hull
	28 Manchester, Salford, Stockport
	29 Liverpool, Birkenhead, Wallasey, Bootle
	30 Rochdale, Oldham, Bury, Bolton
	31 Stoke-on-Trent
	32 Halifax, Huddersfield, Dewsbury, Wakefield
	33 St Helens, Wigan, Warrington
	34 Birmingham, Smethwick, Dudley, Walsall, West Bromwich, Wolverhampton
IV	35 London, East Ham, West Ham, Croydon
	36 Nottingham, Derby
	37 Sheffield, Rotherham, Barnsley

Indices of Population Density and Domestic Overcrowding

Respiratory disease is likely to be affected, independently of fog, by other urban characteristics. So that the effects of two of the major factors could be taken into account we calculated from the 1951 Census data indices for each area of population density and domestic overcrowding: the number of persons per acre and the percentage of persons living more than two to a room.

Mortality Study

From the Annual Reviews of the Registrars General for England and Wales and Scotland, the number of deaths in the 37 areas for each sex at ages 45–64 from 1948 to 1954 have been extracted and related to the corresponding 1951 Census populations. The diagnostic categories include the main certified causes of respiratory death: bronchitis, pneumonia, pulmonary tuberculosis, and cancer of the lung. Details of these are shown in Table II.

Table II

DETAILED DIAGNOSTIC CATEGORIES USED IN MORTALITY STUDY

Diagnosis	International List Code No.
Bronchitis	500–502
Pneumonia	490–493
Influenza	480–483
Tuberculosis of Respiratory System	001–008
Malignant Neoplasm of Trachea, Lung, and Bronchus (England and Wales only)	162,163

Influenza was included, although the deaths are few, so that its pattern could be compared with that of sickness absence from the same certified cause.

The independent associations between the mortality rates and the indices of pollution, population density, and domestic overcrowding have been expressed by second order product-moment correlation coefficients which allowed for variation in the other two factors. Any skew distributions were brought to approximate normality by transformations of the general type $\log(a + x)$, where the value of a was chosen to bring the median of the distribution to the mid-point of the range (Table III).

Table III

CORRELATION OF RESPIRATORY MORTALITY AT AGES 45–64 WITH INDICES OF AIR POLLUTION, POPULATION DENSITY, AND DOMESTIC OVERCROWDING, IN 37 AREAS OF THE UNITED KINGDOM

Product-moment Correlation Coefficients, allowing for Variation in the Other Two Factors

Diagnosis	Sex	Fog Index	Persons per Acre	Per cent. Persons More than Two per Room
Bronchitis	M	+·60**	+·25	+·28
	F	+·57**	+·07	+·27
Pneumonia	M	+·51**	+·46**	+·15
	F	+·33	+·28	+·26
Influenza	M	+·23	−·01	+·06
	F	+·33	−·09	+·04
Pulmonary Tuberculosis	M	+·02	+·65**	+·49**
	F	−·16	+·48**	+·39*
†Cancer of the Lung	M	+·18	+·71**	+·23
	F	+·23	+·59**	−·03

* Significant at 5 per cent. level ** Significant at 1 per cent level
† England and Wales only (35 areas)

The association of *bronchitis* mortality with the fog index in both sexes is highly significant; with population density and domestic overcrowding, it falls below the 5 per cent. significance level.

Male *pneumonia* mortality is significantly correlated with fog and population density; for females, however, the coefficients, although ranked in the same order as for males, are not significantly high.

Because there are so few certified deaths, any relationship between *influenza* mortality and the other indices may be obscured; but the ranking of the coefficients is similar in both sexes and the correlations are greatest with fog.

Fog bears no direct relationship to *pulmonary tuberculosis* mortality, which shows a significant relationship in each sex to domestic overcrowding.

Death in both sexes from *pulmonary tuberculosis* and *cancer of the lung* shows high associations with population density.

Neither male nor female *lung cancer* death rates show any relation to fog or domestic overcrowding.

Use of Routinely Collected Post Office Data

All 412 Postal Head Offices in the United Kingdom render an annual return showing the number of staff and the number of days lost through sickness absence in different grades. Through the kindness of the Deputy Treasury Medical Adviser, Dr. M. C. W. Long, and the Post Office authorities, we were provided with these data for the years 1948–1954. These allowed the calculation of "total sickness" rates for postmen grouped according to their place of work. As in the Deputy Treasury Medical Adviser's Annual Report, these rates are expressed as the number of days lost per person per year. Dr. Long also gave us access to Treasury Medical Service registers from which were extracted particulars of all postmen dying in the service or prematurely retired between 1950 and 1954 because of bronchitis. By dividing the sum of deaths and retirements by the populations of postmen given in the annual returns, "bronchitis wastage" rates were derived for each of the 37 areas. The age distribution of postmen hardly differed between areas, and the rates were not standardized for age. These "total sickness" and "bronchitis wastage" rates were correlated, in the same way as the mortality rates, with the same environmental indices. The results are shown in Table IV (overleaf).

The most serious index of bronchitic morbidity, given by the *bronchitis wastage*, is like the mortality rate, significantly correlated only with fog.

Total sickness shows significant associations with both fog and population density.

TABLE IV

CORRELATION OF "TOTAL SICKNESS" AND "BRONCHITIS WASTAGE" RATES IN POSTMEN WITH INDICES OF AIR POLLUTION, POPULATION DENSITY, AND DOMESTIC OVERCROWDING, IN 37 AREAS OF THE UNITED KINGDOM

Product-moment Correlation Coefficients, allowing for Variation in the Other Two Factors

Rate	Fog Index	Persons per Acre	Per cent. Persons More than Two per Room
Total Sickness	+·36*	+·39*	+·13
Bronchitis Wastage	+·41*	−·03	+·02

* Significant at 5 per cent. level.

SAMPLE SURVEY OF CIVIL SERVICE SICKNESS ABSENCE

More detailed information on age and diagnosis is available from a sample survey of sickness absence incurred in the Civil Service during 1946–53. The sickness records of all permanent civil servants born on the 19th day of any month who had served at any time during that period provided a quasi-random sample of about 3 per cent. For mechanical sorting, the particulars of each absence ending during the 8 years (diagnosis, and dates of onset and return to work) were punched on a card, together with the officer's grade, age, place of work, and other personal details.

To study differences between men doing indoor and outdoor work, and between men and women doing the same work, we took three large sections of the Civil Service: postmen, male clerical and executive staff, and single female clerical and executive staff. For brevity the last two groups are referred to as "indoor males" and "indoor females". The total man-years of service for these populations available from the sample are shown in Table V. Because of social factors affecting the absence pattern of married women, a better sex comparison is obtained by using the data for single women only. We have also excluded staff of 60 years old and over; because of the option of retirement at that age with immediate payment of pension, those who remain are a selected group.

TABLE V

SAMPLE SURVEY OF CIVIL SERVICE SICKNESS ABSENCE

Populations by Age and Occupational Group (man-years)

Age Group (yrs)	Occupational Group		
	Postmen	Indoor Males	Indoor Females
15–	1,530	2,005	3,208
25–	2,366	7,064	3,361
35–	3,017	4,613	2,446
45–	3,987	8,629	2,030
55–59	1,394	4,170	500

For these three populations the sample survey provided attack rates averaged over the 8 years for all absences certified as due to the main categories of respiratory illness. These categories, chosen to give rates based on reasonable numbers, are shown in Table VI. It may be noted that they differ from those of the mortality study. Diseases such as cancer of the lung and pulmonary tuberculosis cause few spells of sickness absence; conversely, very few deaths are certified as due to upper respiratory disease and comparatively few from influenza. Moreover, the same diagnosis which appears in certificates of both death and sickness absence may indicate illness that is different in kind as well as degree. Thus deaths from influenza are due chiefly to its pulmonary complications, while sickness absence generally relates to the uncomplicated initial illness.

TABLE VI

SAMPLE SURVEY OF CIVIL SERVICE SICKNESS ABSENCE

Detailed Diagnostic Categories used in Study of Respiratory Attack Rates

Diagnosis		International List Code No.
(1) Lower Respiratory Group	Bronchitis	500–502
	Pneumonia	490–493
(2) Upper Respiratory Group	Acute nasopharyngitis (common cold)	470
	Acute pharyngitis, tonsillitis, etc.	472, 473, 510
	Diseases of the ear and mastoid process	390–398
(3) Influenza		480–483

In four areas, the sample populations were too small for analysis in this detail. Correlation coefficients were again calculated with the same indices but only in the remaining 33 areas. As in the case of postmen, age-standardization was unnecessary for indoor males, but for indoor females we used a standardized ratio of the observed attack rate in each area to that expected in the same population at total sample survey age-sex specific rates. The results are shown in Table VII (opposite).

Variability due to the rather small numbers of staff sampled in each may have reduced the number of significant results, and these respiratory attack rates are more usefully studied in the section that follows.

The only formally significant relationships are those of *influenza* with domestic overcrowding in both male populations. Despite this, the pattern of these coefficients can with advantage be compared with previous results.

The association of *bronchitis and pneumonia* absence with fog approaches significance in all three

TABLE VII

SAMPLE SURVEY OF CIVIL SERVICE SICKNESS ABSENCE: CORRELATION OF RESPIRATORY ATTACK RATES IN THREE OCCUPATIONAL GROUPS WITH INDICES OF FOG, POPULATION DENSITY, AND DOMESTIC OVERCROWDING IN 33 AREAS OF THE UNITED KINGDOM

Product-moment Correlation Coefficients, allowing for Variation in the Other Two Factors

Diagnosis	Occupational Group	Fog Index	Persons per Acre	Per cent. Persons More than Two per Room
Bronchitis and Pneumonia	Postmen ..	+·32	+·30	+·14
	Indoor Males	+·29	−·15	·00
	Indoor Females	+·36	−·18	+·10
Colds, Sore Throat, etc.	Postmen ..	+·24	+·05	+·10
	Indoor Males	−·31	+·29	−·02
	Indoor Females	−·24	+·28	−·29
Influenza	Postmen ..	+·12	+·26	+·43*
	Indoor Males	−·32	+·21	+·42*
	Indoor Females	·00	+·18	−·12

* Significant at 5 per cent. level.

populations, repeating at a lower level the significant relationship to fog of bronchitis wastage and death.

Colds and sore throats present no features of interest.

ANALYSIS OF MORBIDITY SAMPLE DATA BY AGE AND PRESUMPTIVE AIR POLLUTION

For the more detailed analysis of morbidity in relation to air pollution, age, sex, and job, the 37 areas were ranked according to the level of the fog index and divided into quartiles with nearly equal populations as shown in Table I. Within each of the pollution groups of areas age-specific attack rates were calculated for the same diagnostic categories in each Civil Service population. To show the trend of sickness in relation to air pollution, age-standardized attack rates were calculated by averaging these age-specific rates within each pollution group. Conversely, averaging the age-specific rates over the four pollution groups gave the age-trend in morbidity after allowing for differences between these groups in their age structure.

Table VIII and Fig. 2 (overleaf) show the age-standardized attack rates for each diagnostic category plotted against the logarithm of the median fog index in each pollution group.

Table IX and Fig. 3 (overleaf) show attack rates in the same populations, standardized for the fog index, in five age groups from 15 to 59 years.

Bronchitis and pneumonia attack rates in Postmen and Indoor Males are closely similar in Fog Groups I and II; but there is a wide gap between the attack rates for postmen and indoor males in the more foggy districts. The attack rate for indoor males, unlike that for postmen, shows no rise with age until 35–44 yrs. It then rises in parallel with that for postmen. Indoor males thus have about the same attack rate as postmen 20 years younger. There is little difference between indoor males and females in any pollution or age group; the slight female excess in early life and male excess after age 45 is barely significant.

For *colds, sore throats, etc.* the rate for postmen diverges from that for indoor males with increasing pollution and the gap widens relatively and absolutely from Fog Group I to IV. In contrast to that for bronchitis and pneumonia, however, the attack rate in both occupations is highest at 15–24 years and decreases progressively with age. The curve is steeper in postmen and the absolute and relative gap between the two rates progressively decreases. There is an indoor female excess over indoor males at all ages but especially before 35 years.

The *influenza* attack rate shows a difference between postmen and indoor males, which is unaffected by age but is relatively large in Fog Groups III and IV. There is no important difference between indoor males and females.

TABLE VIII

SAMPLE SURVEY OF CIVIL SERVICE SICKNESS ABSENCE: LOCAL FOG FREQUENCY AND RESPIRATORY DISEASE INCIDENCE

Age-standardization Attack Rates per 1,000 Man-years

Diagnosis	Occupational Group	Fog Group I	II	III	IV
Bronchitis and Pneumonia	Postmen ..	40	53	115	122
	Indoor Males ..	32	41	47	39
	Indoor Females	37	49	51	52
Colds, Sore Throats, etc.	Postmen ..	75	84	113	171
	Indoor Males ..	53	51	63	64
	Indoor Females	77	109	98	115
Influenza	Postmen ..	131	124	197	184
	Indoor Males ..	88	81	90	102
	Indoor Females	90	122	105	102

TABLE IX

SAMPLE SURVEY OF CIVIL SERVICE SICKNESS ABSENCE: RESPIRATORY DISEASE INCIDENCE BY AGE

Attack Rates per 1,000 Man-years Standardized for Local Fog Frequency

Diagnosis	Occupational Group	Age Group (yrs) 15–24	25–34	35–44	45–54	55–59
Bronchitis and Pneumonia	Postmen ..	34	58	83	120	154
	Indoor Males	24	18	33	67	76
	Indoor Females	30	33	42	74	65
Colds, Sore Throats etc.	Postmen ..	143	138	110	79	56
	Indoor Males	69	61	57	51	45
	Indoor Females	164	104	74	73	65
Influenza	Postmen ..	126	193	176	147	149
	Indoor Males	71	85	103	98	99
	Indoor Females	118	83	108	124	78

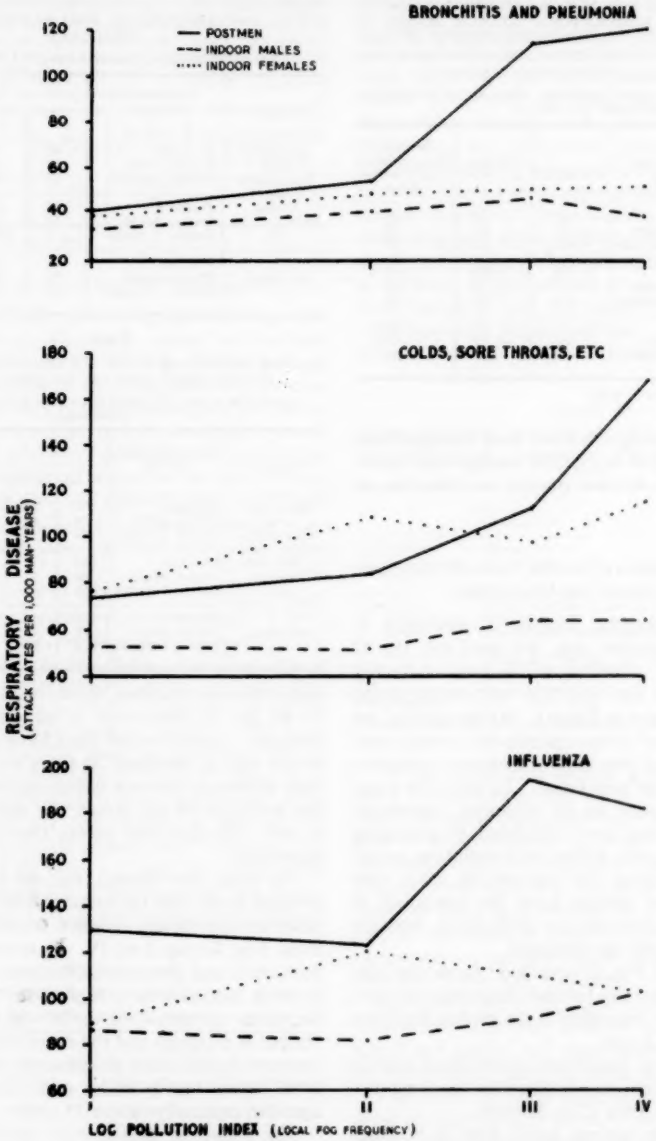

FIG. 2.—Local fog frequency and respiratory disease incidence, by occupation.

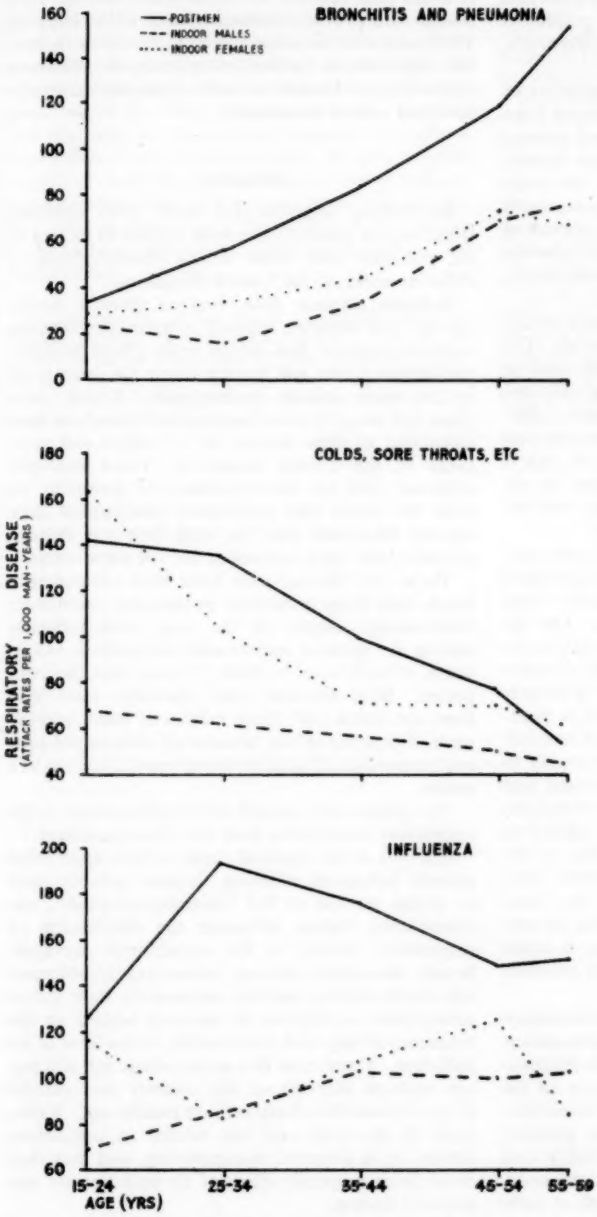

FIG. 3.—Respiratory disease incidence, by age and occupation.

DISCUSSION

The prime interest in this study lay in the effects of air pollution and other features of urban life on respiratory disease and mortality. The interpretation of the results largely depends on the consistency of the patterns observed. From each source of data has come evidence on the relevance of air pollution to respiratory disease. Severe chronic bronchitis, causing disablement or death amongst postmen or death among middle-aged men and women in different parts of the country, is, for example, specifically related to the frequency of winter fog in the same areas. Pneumonia mortality among males is significantly and independently associated with fog frequency as well as with population density. The death rates in both sexes from influenza, so commonly lethal in bronchitics, are associated, although not significantly, with fog rather than with the other local indices. Sickness absences from bronchitis and pneumonia among all grades of staff also bear a consistent, though not a technically significant, relation to fog. Among postmen working out of doors in areas of high presumptive air pollution, the bronchitis and pneumonia absence rate is much higher than among male indoor staff. Colds and sore throats show the same selective incidence in postmen in these more polluted areas. The steady rise with age in the bronchitic absence rate among postmen contrasts with an increase in male indoor workers which occurs only after the age of 45. The complementary age trends in upper and lower respiratory disease, which suggest more frequent chest complications with advancing age, are especially marked among postmen. All these findings are consistent with a specific effect on outdoor staff of exposure to fog and, presumably, to air pollution. This seems reasonable, for not only may outdoor levels of pollution be greater but the physical demands of the postman's round increase the amount

of such air inhaled. Early duty may also expose him to morning peaks in the concentration of pollutants (Department of Scientific and Industrial Research, 1955).

On the other hand, the independent relation of these rates to population density may well result from variation in morale and sickness absence in general with the size of the working group (Acton Society Trust, 1953). Morale may be better in the small rural offices where the contact between management and staff can be more personal. Similarly, a peak at the menopausal age in all female sickness absence rates is of a general nature and not restricted to any particular diagnostic category.

An urban excess in respiratory disease could be due to increased opportunities for infective contact. The higher influenza attack rates among male staff in areas with much domestic overcrowding, like the corresponding death rates from pulmonary tuberculosis, emphasize the importance of cross-infection in respiratory morbidity. The absence of such a correlation among single female staff may be explained by the lesser risk of their contact with infection from school children in the home.

Increased opportunities for cross-infection outside the home might be suggested by the correlation between population density and mortality from pulmonary tuberculosis and pneumonia. On the other hand, the corresponding correlation for cancer of the lung can hardly have the same basis. Neither pulmonary tuberculosis nor lung cancer is directly related to local fog frequency. No support is therefore given to the suggestion of Stocks and Campbell (1955) that air pollution contributes appreciably to the genesis of lung cancer. Lowe (1956) found that the notification rate for pulmonary tuberculosis among older subjects of both sexes was related to smoking frequency which suggests that this is the urban factor common to middle-age mortality both from this disease and from cancer of the lung. Although, according to a recent report, the current urban-rural gradient in cigarette smoking is small (Todd, 1957), it may have been greater in previous decades.

Smoking could also explain the relationship between male pneumonia mortality and population density, particularly in view of the possible diagnostic confusion with lung cancer. No evidence on the effect of smoking on the incidence of bronchitis emerges from this study. The urban-rural gradient in bronchitic mortality or serious morbidity can be explained by local variations in fog frequency. The excess of bronchitic morbidity in indoor male staff over 45 years of age compared with their female colleagues, which might be attributable to smoking (Oswald and Medvei, 1955), is small, though consistent with previous findings (Reid, 1956; Higgins, 1957) and with the excessive male mortality in later life. But without further information, the relevance of smoking to bronchitis in the occupational groups surveyed cannot be assessed.

Summary

Respiratory sickness and death rates obtained from various sources have been related to indices of air pollution and other urban characteristics in different areas of the United Kingdom.

Sickness absence data, derived from a survey among civil servants, allowed comparisons between outdoor postmen and indoor male officer workers, and between men and women doing the same work in the same indoor environment. Attack rates from four major types of respiratory illness have been calculated in these groups for 37 urban and rural areas of the United Kingdom. From routinely collected data on the experience of postmen, the rates for death and permanent disablement from chronic bronchitis and the total time lost through sickness have been calculated for the same areas.

These Civil Service data have been collated with death rates from bronchitis, pneumonia, pulmonary tuberculosis, cancer of the lung, and influenza among the general middle-aged population (45–64 years) of both sexes in these 37 areas over the same period. Both mortality and morbidity rates have been correlated with three indices of local environment; frequency of fog, number of persons per acre, and percentage of persons living more than two to a room.

The trends with age and with fog frequency in the respiratory attack rates have also been examined.

Analysis of the material suggests that, apart from general influences affecting sickness absence such as group morale or the "menopausal peak", environmental factors influence the distribution of respiratory disease in the populations surveyed. Severe bronchitis causing permanent disablement and death among postmen exposed by their job to atmospheric conditions is uniquely related to the frequency of fog, and, presumably, to the level of air pollution. These rates in a group whose job and pay are uniform throughout the country run parallel to local bronchitis death rates in middle age. Variations in the latter are not related to population density or to domestic overcrowding, and may thus result from a specific effect of air pollution on respiratory disease.

The high incidence of influenza morbidity and tuberculosis mortality in areas with much domestic

overcrowding emphasizes the importance of cross-infection in the home. Some of the excessive urban mortality from pulmonary tuberculosis and pneumonia may also be due to increased opportunities for infection; but the singular association of lung cancer mortality with population density and not with fog index of air pollution suggests that urban-rural differences in smoking habits may have affected the risk of death from three major causes of respiratory mortality: lung cancer, pulmonary tuberculosis, and, perhaps, pneumonia. The relevance of smoking habits to bronchitis could not be assessed from the available data.

We are grateful to Dr. W. E. Chiesman, Treasury Medical Adviser, for his encouragement, and to the Treasury and the Post Office for their co-operation and permission to use and publish the data. We are indebted to the Treasury for arranging the machine tabulation, and to the staffs of the units concerned. We received ready help at every stage from the staff of the Treasury Medical Service.

Mr. Daly, formerly of the M.R.C. Social Medicine Research Unit, kindly made available the details of the pollution index used in his study.

Miss Doreen Bobby and Mrs. Barbara Hunt did the computing work, and Mrs. Sheila King gave secretarial help and drew the diagrams.

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ATMOSPHERIC POLLUTION AND MORTALITY IN THE COUNTY OF LONDON

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The pattern of mortality in the County of London differs from that in the country as a whole. The difference cannot be wholly explained by diagnostic fashion (Hewitt, 1957) or by differences in the social class composition of the two populations.

There was not a great difference at the time of the 1951 census between the proportions of the Registrar General's Social Classes I to V in London and those in England and Wales. If Classes I and II and Classes IV and V are combined to form a three-fold classification there is almost perfect correspondence between the two areas.

As will be seen from Table I, which shows the pattern for the year 1955, the differences in detail are that in London male mortality is higher and female mortality lower than in England and Wales. The excess male mortality is concentrated mainly in the age group 45–64 years, whilst female mortality is lower at all ages and especially at 65 years and over. Examination of the disease pattern shows, for males, an excess of deaths from diseases of the respiratory system which increases with age. The excess is offset to some extent by fewer deaths from cardiovascular causes, but the mortality ratio for all causes at all ages is 3 per cent. higher in London than in the whole country, and at ages 45–64 years it is 8 per cent. higher. For females, a similar though not so pronounced pattern, is found, and the fewer cardiovascular deaths more than offset the higher ratios from diseases of the respiratory system, resulting in a female mortality for all causes at all ages which is lower than that for the whole country.

TABLE I

STANDARDIZED MORTALITY RATIOS, LONDON A.C., 1955, FOR ALL CAUSES AND CERTAIN DISEASES (ENGLAND AND WALES = 100)

Sex	Age Group (yrs)	All Causes	Bronchitis	Other Respiratory Diseases (including respiratory tuberculosis)	Lung Cancer	Other Cancer	Cardiovascular Diseases
Male	Birth to 4	100	250	81	—	(115)	(50)
	5–44	93	104	76	123	108	92
	45–64	108	132	110	131	117	94
	65 and Over	102	149	139	155	113	86
	All Ages	103	145	120	143	114	88
	Excess or Deficiency of Deaths	+548	+606	+287	+458	+321	−1,059
Female	Birth to 4	97	(163)	78	—	(109)	(100)
	5–44	97	(67)	82	(118)	102	93
	45–64	96	107	99	186	106	82
	65 and Over	92	127	127	181	102	85
	All Ages	93	124	115	180	104	85
	Excess or Deficiency of Deaths	−1,337	+180	+187	+150	+117	−1,621

Figures in brackets based on fewer than twenty deaths in either actual or expected mortality, and ratios, therefore, unreliable.

Methods

There are in London numerous atmospheric pollution recording stations, but the methods of measurement differ, not only as regards the instruments but also as regards the time-intervals at which they are read. A preliminary analysis of data from these sources showed that, because of the differing methods of measurement and the siting of the instruments at different heights for particular local purposes, it would be fallacious to accept data from any one or any combination of these instruments as representative of a wider area. Daly (1954) referred to the unsatisfactory nature of pollution records and used instead figures of the consumption of domestic coal per acre.

In 1953 an automatic sampler was devised in the Council's Scientific Adviser's laboratory. The apparatus consists of a multiple-circuit set of volumetric apparatus for the dual measurement of smoke and sulphur dioxide. Up to six consecutive samples can be taken before filters and solution need to be examined and renewed, and this facilitates the study of peak concentration of pollutants and enables detailed observations to be made without manual attention during the night and the week-end. Seven of these instruments were installed at the end of 1954, one at each of the Council's six general ambulance stations and one at County Hall, all at the same level above ground. None of them was deliberately located to measure a particular local source of pollution.

It was decided to centre the investigation on these seven recording stations, and to use the mortality data of the areas immediately surrounding them for the study of the long-term effect of atmospheric pollution. The recording stations and associated areas are shown in Fig. 1, and the details are set out in Table II.

Practical difficulties in the calculation of mortality rates dictated that the associated areas should be either metropolitan boroughs or parliamentary constituencies, and the shape of the areas reflects these limitations. Moreover, having regard to the prevailing wind from the south-west, the instruments may not have been recording the pollution generated within the area but that in the air which was blown over them. Nevertheless, they measured samples of the air that the residents in the area had to breathe.

The populations used as a basis for the investigation were, for complete boroughs, the Registrar

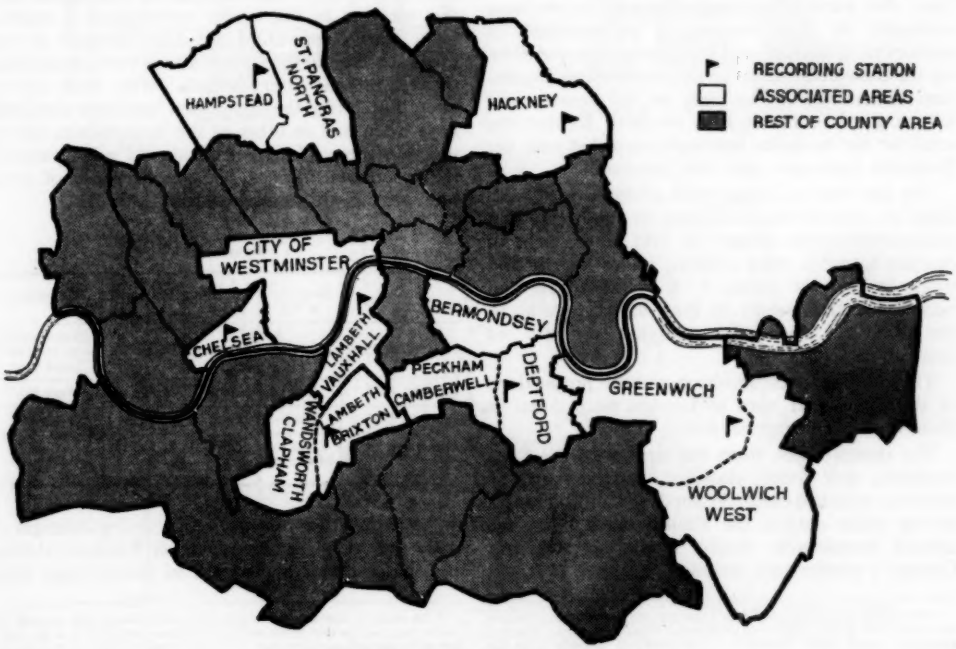

Fig. 1.—Air-pollution recording stations and associated areas.

TABLE II

Recording Station	Associated Area(s)
North-western Ambulance Station, Lawn Road, Hampstead	Borough of Hampstead. Parliamentary constituency of St. Pancras North
Eastern Ambulance Station, Brooksby's Walk, Hackney	Borough of Hackney
Brook Ambulance Station, Park Row, Shooters Hill Road, Greenwich	Borough of Greenwich and parliamentary constituency of West Woolwich
South Eastern Ambulance Station, New Cross Road, Deptford	Borough of Bermondsey. Borough of Deptford and parliamentary constituency of Peckham Division of Camberwell
South-western Ambulance Station, Landor Road, Stockwell, Lambeth	Parliamentary constituencies of Brixton Division of Lambeth and Clapham Division of Wandsworth
County Hall, Westminster Bridge, Lambeth	City of Westminster
Average of South-western and County Hall Stations	Parliamentary constituency of Vauxhall Division of Lambeth
Western Ambulance Station, 350 Kings Road, Chelsa	Borough of Chelsea

General's mid-1955 estimates of the home population. For parts of boroughs the populations were estimated by a conversion of the numbers of electors as at November, 1955, into total population, on the basis of the ratio of electors to total population ascertained at the time of the census, and adjusting the numbers thus obtained so that the total for the complete boroughs accorded with the Registrar General's mid-1955 estimate.

The age and sex composition of the area populations so assessed was calculated by modifying that ascertained at the census* of 1951 in the light of changes (notably fewer children under 5 years and more in the age range 5–14 years) which had occurred in the County by mid-1955, according to the Registrar General's mid-year estimate of population.

The social class composition and the proportions of the population born in London were taken as those found at the census date.

The deaths taken from the returns of the local registrars were coded, classified, and tabulated by means of punched cards. When deaths of Londoners taking place outside the County were used, the inward transferable deaths from the Registrar General's returns were included.

* For parts of boroughs for which the sex and age composition was not tabulated in the census volumes information for areas approximating to those under examination was obtained specially from the Registrar General.

In considering the short-term aspect of atmospheric pollution, all deaths occurring in London were used, irrespective of place of residence, during certain parts of the period October, 1954, to March, 1957. For other comparisons, the mortality data consisted of all deaths of residents of the areas listed above, wherever the person might have died, during the 2-year period October 1, 1954, to September 30, 1956.

RESULTS

Fig. 2 (opposite) shows mean daily concentrations of smoke and sulphur dioxide at the seven recording stations, highest and lowest temperatures for four foggy periods experienced since the beginning of this investigation, and average levels of pollution in the two winters (October to March) of 1954–55 and 1955–56. There is no accepted definition of what constitutes a fog, and the criterion adopted was an average daily reading of all seven stations in excess of 100 milligrams of smoke per 100 cubic metres of air *and* 20 parts of sulphur dioxide per 100 million parts of air (*i.e.* about double the customary winter level) on any of 2 days within a period of 7 consecutive days. The days surrounding these high readings on which there was any mention of fog in the meteorological reports from Kew Observatory are also included in the diagram. Not all the seven stations were functioning throughout the four periods. Two were not in operation during the first period and there were odd days when one or other of the stations was out of use, but these minor defects should not invalidate the broad conclusions. The characteristics of these four periods are summarized in Table III.

TABLE III

Period	Intensity of fog	Duration	Pollution	Temperature
November, 1954	Moderate	Medium	Moderate	Comparatively high in spite of night frost
January, 1955	Light	Long	Moderate	Very low
January, 1956	Thick	Short	Heavy	Low
December, 1956	Light to Moderate	Long	Moderate	Low

Fig. 3 (overleaf) shows 7-day moving averages of daily deaths of persons dying *in* London† during periods of about one month of which foggy days

† An analysis was made of events in the individual area around the recording stations (the areas used in the 2-year analysis), but the number of deaths was so small that, even on a weekly basis, the fluctuation was so great that nothing useful could be extracted.

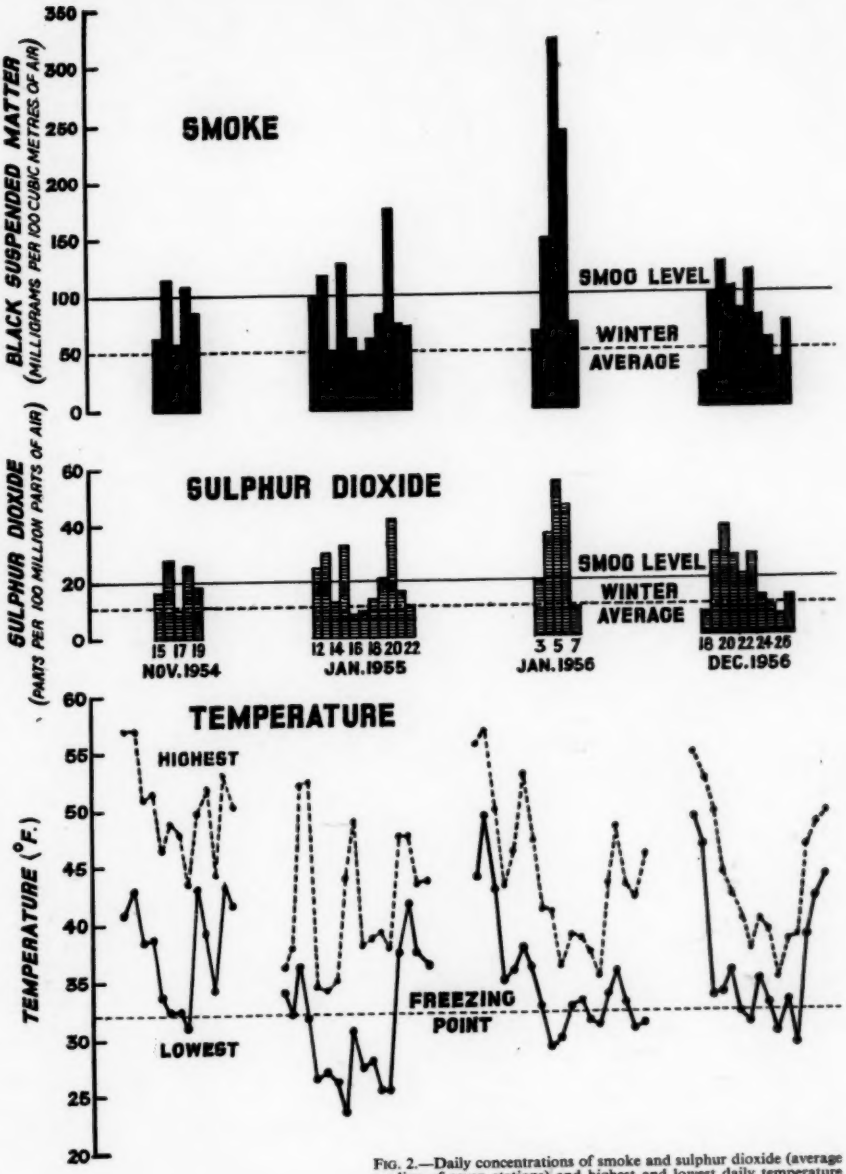

FIG. 2.—Daily concentrations of smoke and sulphur dioxide (average reading of seven stations) and highest and lowest daily temperature (recordings from Kew Observatory) in four foggy periods.

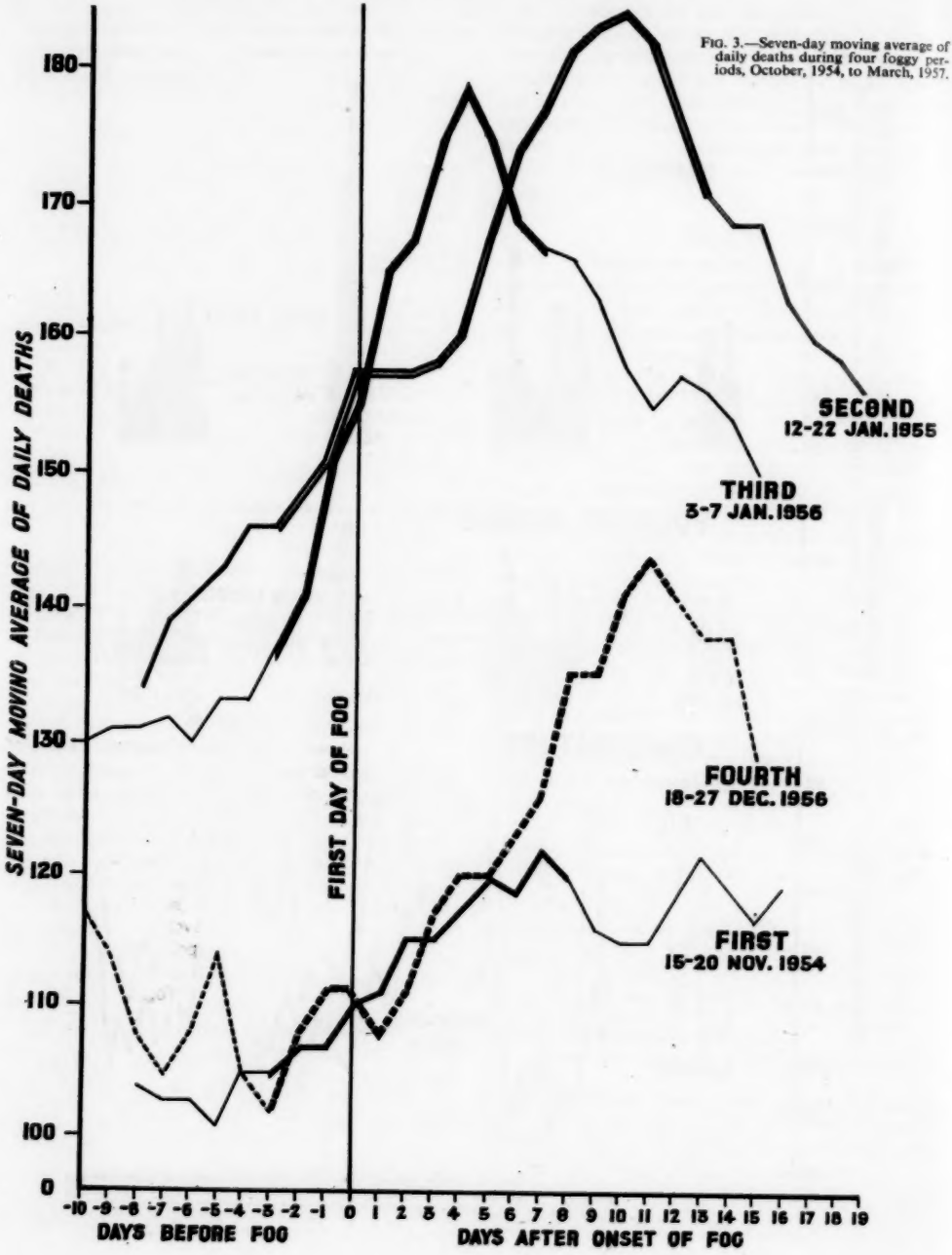

FIG. 3.—Seven-day moving average of daily deaths during four foggy periods, October, 1954, to March, 1957.

form the central section. The day of onset of fog is indicated by the vertical line at Day 0, and preceding days by –1, –2, etc. These curves, centred as they are on deaths 3 days either side of the day indicated, reflect any rise or fall in mortality before or after the event and for this reason the thick lines extend to three days either side of the fog. The moving averages shown are based on actual figures for the County as a whole, except that for the fog of December, 1956, which is an estimate based on the areas associated with measuring stations.*

Judging from the difference between deaths registered in, and allocated to, London, there is a yearly net surplus of about 3,700 deaths of non-Londoners in London hospitals. Therefore the number of deaths *occurring in* London cannot be related to a population for the production of rates. Hence, for the purpose of estimating the short-term effect of a fog, it was necessary to consider whether or not there was a rise in the level of mortality.

Quite clearly there was a rise in all four episodes, but there is no apparent similarity between them. In the first and fourth fogs deaths continued at the higher level after the end of the foggy period and in the fourth the rise continued upwards.

These differences were only to be expected, because the level of atmospheric pollution was not the sole factor operating during the duration of the "smog" as defined. Temperature is another factor that must be considered. Moreover, it is extremely difficult to estimate the course that mortality would have followed in the absence of a smog.

More often than not cold and fog occur together. Russell (1924) found this difficulty in his survey of fog in Islington and St. Pancras over the years 1870–1900. During the occurrence of a winter fog the night temperature is usually depressed to around freezing point, but in the January fog of 1955 the level went well below freezing and the daytime temperatures also tended to be low (Fig. 2). The differences between the second and third fogs were that January, 1955, was much colder than January, 1956, and pollution was much heavier in 1956 than in 1955.

According to Wilkins (1954):

"The problem of smog is, in some respects, a short-term magnification of the general problem of atmospheric pollution, and because the effects of normal pollution are ever present they undoubtedly represent, in the long run, a greater damage and loss to individuals and to the nation than does an occasional smog incident".

Because of a suspicion that some effects of atmospheric pollution were purely local and in order satisfactorily to calculate any correlation between it and mortality, standardized mortality ratios were calculated for the 2-year period October, 1954, to September, 1956, and were set against the figures of atmospheric pollution for the same period for each of the areas referred to earlier.

Table IV (opposite) sets out the populations for the different areas by sex, with the percentage in the Registrar General's Social Classes IV and V, the percentage born in London, the average pollution during the whole period of 24 months†, and standardized mortality ratios (calculated on the mortality experience of the whole County) for the causes of death already listed in Table I. The sexes have been separated because of the different mortality experience already demonstrated in Table I.

Social class has been included as an index of socio-economic conditions, and the percentage of the population born in London as an index of duration to exposure of the population of the areas to the London atmosphere. This latter index takes no account of migration inside the County; nor do current figures of atmospheric pollution necessarily correspond to conditions in the past because of changes in the nature of the activities, commercial, industrial or residential of the area.

Discussion

Fig. 3 suggests that the short-term effects of only the second and third fogs merit serious consideration, *i.e.* the fogs of January, 1955, and January, 1956. The Ministry of Health report on the smog of December, 1952, showed that there was, on that occasion, an excess of deaths in old people (Ministry of Health, 1954). As will be seen from Fig. 4, (opposite), showing the percentage of deaths in persons aged 70 years and over for these two fogs and in the very cold fog-free spell of February, 1956 (when the overall mortality reached a higher level than during either of the two fogs), the smog of January, 1956, was outstanding in its effect on old people. Quite apart from the fact that the cold spell had less effect on old people, the effect on the causes of death during the two periods were different. In the period of the smog, and in the 2 weeks immediately following it, the biggest proportionate rise was in bronchitis, whereas in the cold weather of February the biggest rise was in

* By the time of the last episode it had been decided to concentrate solely on the seven multiple-circuit volumetric stations and the associated areas, which had been found to be a representative cross-section of the London population as regards sex and age structure and social class. During the first three fog periods about one-third of the deaths occuring in London took place in these areas.

† The co-efficient of variation was remarkedly consistent whether calculated on summer, winter, yearly or two-yearly means.

TABLE IV

VARIOUS INDICES OF POPULATION, ATMOSPHERIC POLLUTION, AND STANDARDIZED MORTALITY RATIOS FOR DEATHS FROM ALL CAUSES AND CERTAIN DISEASES FOR THE 2 YEARS ENDING SEPTEMBER 30, 1956

Area	Sex	Population			Index of Atmospheric Pollution		Standardized Mortality Ratios (*a*) (London = 100)					
		Estimated Number Mid-1955 (*b*)	Percentage in Social Classes IV & V (Census, 1951)	Percentage Born in London (Census, 1951)	Smoke (*c*)	SO_3 (*d*)	All Causes	Bronchitis	Other Respiratory Diseases (including respiratory tuberculosis)	Lung Cancer (*e*)	Other Cancer	Cardiovascular Diseases
Hampstead	M	40,900	15·4	40	33	7·1	91±2·9	53± 7·4	58± 7·6	69± 9·0	83± 7·6	83±4·4
	F	56,810		34			81±2·5	67±10·1	59± 7·8	(74±17·9)	76± 5·8	83±3·9
St. Pancras North ..	M	40,700	32·5	64	33	7·1	99±3·1	108±10·6	120±11·0	105±11·5	99± 8·4	94±4·7
	F	45,300		64			92±3·1	88±13·5	85±10·8	(113±26·5)	102± 7·7	89±4·3
Hackney	M	78,900	26·0	76	37	7·1	96±2·2	133± 8·7	69± 6·2	88± 7·7	103± 6·3	99±3·5
	F	88,300		75			96±2·3	108±11·1	83± 7·9	78±15·6	106± 5·8	99±3·4
Greenwich and West Woolwich	M	82,970	28·4	63	25	5·6	80±2·0	71± 6·2	85± 6·7	82± 6·0	85±5·6	78±3·1
	F	87,020		65			79±2·1	84± 9·7	89± 8·2	(48±12·5)	78±5·0	77±3·0
Bermondsey	M	28,320	45·1	81	37	8·0	99±3·9	93±12·6	98±12·6	106±14·7	99±10·5	99±6·2
	F	29,260		85			93±4·0	97±18·2	71±12·6	(50±22·4)	102±10·1	95±5·9
Deptford and Peckham Division of Camberwell	M	76,840	35·6	77	37	8·0	106±2·4	129± 8·7	107± 7·8	137± 9·8	102± 6·4	100±3·6
	F	82,450		77			104±2·5	116±11·8	90± 8·5	103±18·9	109± 6·1	107±3·7
Westminster	M	45,260	26·7	35	21	9·4	88±2·8	49± 6·8	105± 9·9	75± 8·8	99± 7·8	84±4·2
	F	52,370		35			81±2·7	39± 8·4	87±10·3	100±21·8	87± 6·5	74±3·7
Vauxhall Division of Lambeth	M	33,000	32·6	66	30	9·2	106±3·6	118±12·6	144±13·9	116±13·8	84± 8·8	106±5·7
	F	35,300		67			99±3·7	114±17·8	121±15·1	(131±31·7)	94± 8·6	96±5·3
Clapham Division of Wandsworth and Brixton Division of Lambeth	M	74,650	31·0	66	39	9·0	110±2·4	86± 7·1	90± 7·2	166±11·0	168± 8·3	94±3·6
	F	81,600		66			126±2·8	106±11·3	112± 9·5	190±25·6	223± 8·7	102±3·6
Chelsea	M	21,420	23·2	49	37	11·3	123±4·6	67±11·1	104±13·9	88±14·3	146±13·6	126±7·1
	F	30,030		41			123±4·1	92±15·6	143±16·0	(100±27·7)	107± 9·3	125±5·9

Notes: (*a*) Nine age groups were used in the calculation of the standardized mortality ratios (*viz.*, Birth to 4 years, and 10-year groups from 5–14 to 75+ years).
(*b*) *i.e.* 9 months from the beginning and 15 months from the end of the 2 years.
(*c*) Mean daily value of milligrams of black suspended matter per 100 cubic metres of air.
(*d*) Mean daily value of parts of sulphur dioxide per 100 million parts of air.
(*e*) Figures in brackets are based on fewer than twenty deaths in either actual or expected mortality, and the ratios are unreliable.

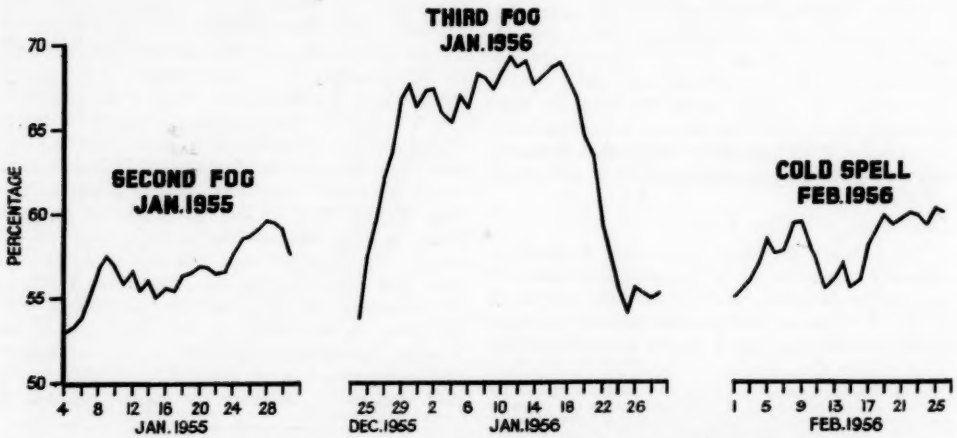

FIG. 4.—Proportion of deaths at 70+ years to total deaths (proportion from seven-day moving averages).

cardiovascular diseases. But it must also be mentioned that in the week in which the smog occurred there was a rise of 89 in the number of "mentions" of respiratory conditions (not being the underlying cause of death) on death certificates, the biggest corresponding rise in any week of the cold spell being 33.

Logan (1956) estimated that the smog of January, 1956, was responsible for 440 "excess" deaths in the County of London, on the assumption that any deaths in the period January 4 to 14 above the number in the preceding 10 days were caused by the smog. We have obtained a similar answer (480 deaths), but by counting as "excess" deaths those above a rising "level" of mortality, by linking the pre-smog level with the higher level on or around January 27, when the cold spell began.

Whichever estimate is taken, the smog of January, 1956, can be regarded as a lethal fog, particularly for old people. A comparision between this and the other less lethal fogs enables an estimate to be made of the amount of atmospheric pollution that can apparently be tolerated by the population of London, without giving rise to any appreciable immediate excess mortality. The levels are in the region of a daily mean concentration of 200 milligrams of black suspended matter per 100 cubic metres of air together with 40 parts of sulphur dioxide per 100 million parts of air, *i.e.* about four times the average winter level. What cannot be estimated from the data available are the critical levels of either one or the other in isolation. The measures now being taken under the Clean Air Act, 1956, may possibly lead to a reduction of one component in relation to the other and thus permit of an assessment of the respective parts played by smoke and by sulphur dioxide.

In order to see if there is any relation between mortality within London during a 2-year period and the degree of pollution in the atmosphere in this same period, the correlation coefficients were calculated of the various indices tabulated in Table IV. The results are shown in Table V for the first eight areas listed; the two last were omitted because of the presence within them of several institutions in which deaths are not transferable to the former place of residence. This, according to Hewitt (1957), often results in completely unrepresentative death rates and ratios. The problem of non-transferable deaths also exists in the borough of Deptford, but since this borough is joined with the Peckham Division of Camberwell the effect is less serious.

While these numerical expressions of association do not necessarily represent a causal relationship, neither does the lack of correlation imply that the variates are wholly independent. Nevertheless, it is worthy of comment that, in the ten coefficients reaching the 5 per cent. level of significance, the percentage born in London occurs six times (counting each sex separately), index of smoke twice, percentage in Social Classes IV and V once, and sulphur dioxide once. The implication is that percentage born in London, *i.e.* duration of life spent in London, has more bearing on mortality than any of the other indices tested. "Other Cancer" was included in Table IV as a "control" disease; it was not expected that mortality from this cause would be associated with the indices of atmospheric pollution.

It will be appreciated that the various factors do not operate in isolation. Hewitt (1956) combined the index of sulphur dioxide with the percentage born in London to arrive at a composite index for

TABLE V

ZERO ORDER CORRELATION COEFFICIENTS OF VARIOUS INDICES OF POPULATION, ATMOSPHERIC POLLUTION, AND STANDARDIZED MORTALITY RATIOS FOR ALL CAUSES AND CERTAIN DISEASES

Indices of Population	Sex	All Causes (*a*)	Bronchitis (*b*)	Other Respiratory Diseases (*c*)	Lung Cancer (*d*)	Other Cancer (*e*)	Cardiovascular Diseases (*f*)
(1) Percentage in Social Classes IV and V	M	0·485	0·453	0·556	0·707	0·442	0·572
	F	0·547	0·480	0·265	—0·025	0·641	0·474
(2) Percentage Born in London	M	0·532	0·828	0·193	0·710	0·398	0·681
	F	0·707	0·848	0·252	—0·144	0·736	0·738
(3) Index of Smoke	M	0·645	0·680	—0·169	0·511	0·368	0·632
	F	0·688	0·715	—0·271	—0·076	0·668	0·845
(4) Index of Sulphur Dioxide ..	M	0·524	0·037	0·579	0·274	0·193	0·477
	F	0·334	—0·106	0·408	0·903	0·249	0·153

All coefficients positive unless preceded by a minus sign.
5 per cent. level of significance with eight pairs of variables $r = 0{\cdot}707$.

the measurement of the degree of atmospheric pollution and duration of exposure thereto, and he found a significant correlation between deaths from all causes, respiratory causes, bronchitis, cancer of the lung, and heart disease in the nine health divisions of London. A similar approach has been made with the data in this investigation by combining the percentage born in London with the index of smoke and of sulphur dioxide in relation to bronchitis. Bronchitis was chosen because, as can be seen from Table V, there is a significant correlation with the percentage born in London of either sex, a reasonable correlation with smoke, and virtually none with sulphur dioxide. The results are as follows:

Bronchitis and *Percentage born in London* × *Smoke:*

Males $r = +0{\cdot}824$
Females $r = +0{\cdot}836$

Bronchitis and *Percentage born in London* × *Sulphur dioxide:*

Males $r = +0{\cdot}818$
Females $r = +0{\cdot}800$

These results suggest something in the nature of a statistical artefact—sulphur dioxide, which apparently of itself had no bearing on mortality, suddenly becoming highly significant in association with length of residence. The part played by each component of the combined index of residence and smoke was tested by the calculation of first order correlation coefficients which are as follows:

$r_{3b.2}$ = Males $+0{\cdot}232$
Females $+0{\cdot}435$
$r_{2b.3}$ = Males $+0{\cdot}667$
Females $+0{\cdot}726$

None of these partial correlation coefficients, nor of the differences between them, is significant. However, the higher values of r for the correlation of bronchitis with percentage born in London when smoke is held constant suggests that duration of exposure to the London atmosphere is more important in relation to bronchitis than variations in the degree of air pollution within London—London's air is bad for bronchitis no matter in what part of London a person lives. It could be said in relation to these figures that, while they show residence in London to be deleterious, they do not prove the part played by atmospheric pollution. It is however difficult to see what other facet of London life could be pertinent in this connexion. Social class has already been discounted because of the near parity of London with the country as a whole in this respect. Smoking habits must also be considered. It has been shown that the degree of urbanization affects mortality from lung cancer and bronchitis. For example, Stocks and Campbell (1955) found an association between cancer of the lung in males and urbanization; they estimated that three-eighths of male deaths from lung cancer in Liverpool were due to this factor (one half of the deaths were attributable to smoking habits). Eastcott (1956) has drawn attention to the differential death rate from cancer of the lung between immigrants from the United Kingdom in New Zealand and native New Zealanders—a difference that increases with age at immigration, the inference being that there was something in the environment of the United Kingdom early in life that determined the onset of the cancer. The difference is unlikely to be due to smoking habits, because there is a higher consumption of tobacco per head of population in New Zealand than in the United Kingdom.

It could be argued that total mortality is not the right index to use, because any long-term effect of atmospheric pollution will be reflected in deaths at later ages. This aspect has been considered and the standardized mortality ratios calculated for ages 45 to 64 and 65+ years separately for the areas of Table IV. With two exceptions (lung cancer in females aged 65+ years and cardiovascular diseases in males aged 45–64 years), there was no difference in the ranking order between the age group standardized mortality ratios and those for all ages. This is not altogether surprising, because only about 9 per cent. of male and 7 per cent. of female deaths occur at ages under 45 years.

It is fully appreciated that the percentage of population born in London is at best only a rough approximation of the duration of exposure to the London atmosphere. Furthermore it has not been possible to allow for the effects of migration from one area to another, nor for the effect of daily travel to employment. As regards the atmospheric pollution figures, indices other than the means of daily average figures have been suggested. Pemberton and Goldberg (1954) experimented with means of the *maximum* daily readings. Consideration was given to using the proportion of days when pollution was twice the winter average, but there was no significant difference in ranking order of the stations whether by daily average figures or by days of doubled pollution (for smoke R(Spearman) $= +0{\cdot}96$, and for sulphur dioxide $R = +0{\cdot}88$).

Summary

An examination of mortality experienced in London during periods of fog in association with indices of atmospheric pollution suggests a critical

level of four times the customary winter average of atmospheric pollution above which a fog will cause marked immediate excess mortality.

By the methods used in this investigation no significant relationship between mortality and exposure to smoke and sulphur dioxide was demonstrated over a 2-year period. A critical level of one or both in combination that would be directly associated with increased mortality is not thereby excluded. There may also be other types of pollutants more dangerous than either.

Living in London for a long period is considered to increase the risk of dying from respiratory disease, particularly bronchitis. A crude index, percentage born in London, had perforce to be used as a measure of length of residence.

If the Clean Air Act, 1956, has the effect of reducing the amount of smoke in the atmosphere it may be possible to assess with greater clarity the respective parts played by sulphur dioxide and smoke.

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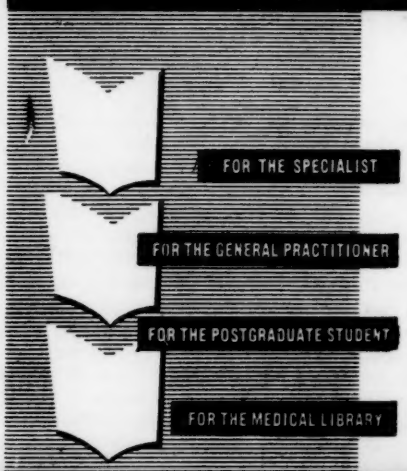

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